CONTENTS

FIELD EXPERIMENTS ON THE CHOICE OF OVIPOSITION SITES OF TWO SPECIES OF *CHORTHIPPUS* (FAMILY ACRIDIDAE)

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Abstract

Field experiments were planned to study the oviposition behaviour of *Chorthippus parallelus* (Zett.) and *Chorthippus brunneus* (Thnbg.) Biological observations on their reproductive behaviour and field methods employed for the egg-pods sampling are described.

The field data suggest the possibilities of choice of oviposition sites by these grasshoppers Their preferences and requirements for selection of oviposition sites are discussed. Both species exhibit different choice of sites for oviposition which is influenced by the soil factors. The preference is very marked in case of *C brunneus* as compared to *C. parallelus*

Introduction

The oviposition sites of a number of grasshoppers occurring in sandy heaths, fields, pastures meadows and other similar habitats are very well marked and some of them show a preference for more precise oviposition sites (Severin and Gibbertson 1917 Criddle, 1933 Waloff, 1950 Richards and Waloff, 1954) Several British grasshoppers have restricted oviposition sites. These sites may be described as bare or semibare patches which are selected for oviposition by mesophilous species *e.g* *Chorthippus vagans* (Eversmann) *C brunneus* (Thnbg.) *C parallelus* (Zetterstedt) *Omocestus ventralis* (Zetterstedt) and *Gomphocerippus rufus* (Linnaeus) Similar localization of *egg-laying sites was observed in Chorthippus albomarginatus (De Geer) Omocestus sp* and *Stenobothrus sp* by Rubtzov (1935 b) in Siberia.

Field experiments were planned to collect data on the choice of oviposition sites by *C parallelus* and *C. brunneus* in their natural habitats The object of present study was to make field observations on th reproductive activities of these grasshoppers and to compare such results with the findings on the oviposition preference of these insects studied in cage experiments under laboratory conditions (Choudhuri, 1958) The study was carried out at the Imperial College Field Station (Silwood Park) Sunninghill, Berks.

Methods

A suitable site in Silwood Park where grasshoppers are usually found was chosen for the present study The area of study was classified into

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seven different treatments (experimental blocks)—natural occurring as bare patches of mosaic pattern type turf (ground covered with short vegetation) ant-hills of *Lasius flavus* (Fabricius) heated bed, earthen mounds of common builder's sand bare and semi bare areas The last four treatments were artificially made in the study area. Hereinafter the respective treatment will be referred as 'plot

(A) *Description of study areas*

A study area (Fig 1) measuring about 1440 sq ft was set up in a permanent grasshopper habitat which has been named as colony No. 1 The area was surrounded on three sides by scattered bushes of broom (*Sarothamnus scoparius* Link.) and on the open side it was separated from the rest of the colony by a narrow permanent field path. Short distance migrations could take place between the two grass-plots. The area was densely covered with vegetation The height of vegetation within the area was fairly tall; it varied from 1 in to 2 ft. It chiefly comprised of common grasses—*Festuca rubra* L. *Agrostis tenuis* Sibth. *Holcus lanatus* L., *H mollis* L., *Dactylis glomerata* L., and *Poa sp* Among other types of vegetation the following herbs were most common—*Achillea millifolium* L. *Ranunculus repens* L. *Stellaria media* Vill *Plantago lanceolata* L. and *Rumex sp*

(B) *Experimental layout*

In the study area two bare and two semi-bare plots were made (Figs. 2 and 3) Each plot was 9 sq ft. in area The former were made by placing a big metal square (9 sq ft. size) and clearing or uprooting the vegetation inside the square without disturbing the existing soil structure to a great extent The latter were made by using the same square but instead of weeding out the vegetation it was cut with a sharp scythe close to the ground About ten natural bare patches of small area (30-40 sq in) were scattered in the study area these constituted a very small fraction of bare ground in the entire study area. Most of these patches were nearly of same size and hence the idea of classifying them into various groups depending on their area was given up The distributional pattern of these patches was of mosaic type

A bed (Fig 4) measuring 6×2 ft was prepared by digging a ditch about 1? in. deep A soil heating coil was burried in it about 6 in deep The bed was kept constantly warm throughout the observation period (for about 2½ months) The surface soil of the bed was divided into two parts—one half being compact and the other half was loose The compact half was rammed frequently similarly the loose half was raked every alternate day The idea of dividing the bed into two halves was to observe differential oviposition response in relation to soil structure and soil-temperature About 2 ft. from the heated bed,

the control bed (artificial bare plot of 9 sq ft.) was located. The ground between two beds was covered with turf.

Sixteen earthen mounds (Fig 5) measuring 2 sq ft. each made of common builder's sand were placed in the study area. These were of hillock types having distinct apex and a broad base these simulated ant hills present in the site. The mounds were fairly well distributed. Six ant hills of *L. flavus* (total area 36 sq ft.) were present in the area. Sparse vegetation was found on these ant hills.

(C) *Measurements*

(i) *Temperature* The surface temperature of soil of the plots was recorded daily at mid-day with a thermo-couple. In Fig 6 the mean temperature of various plots is represented The graph shows the mean six-day temperature for two months (July-September) when the oviposition of these grasshoppers is usually at its peak. The mean temperature of the heated bed during the observation period was about 96·8°F Standard soil thermometers (Negretti and Zambra make) were also used to measure the ground temperature. The bulbs of soil-thermometers were placed just beneath the surface of soil and were protected from direct radiation by covering with layers of dust.

(ii) *Meteorological data.* These data were directly received from the Stevensons' Screen maintained by the Field Station the screen was stationed on an adjacent plot close to the present study area

(iii) *Soil compaction.* The compaction of soil was determined by the soil penetrometer (Choudhuri, 1961)

(iv) *pH values* The determination of pH values of soil were carried out by the B.D.H Barium Sulphate Soil testing outfit using BDH soil indicator

(D) *Methods of finding egg-pods:*

In September (when the oviposition was nearly over) soil samples were collected from various plots in the study area. The standard wire-worm sampler was used (Fig 7) fo digging soil samples This is a device made of steel which scoops core of soil measuring 4×6 in

The following procedure was adopted during egg-pod sampling As far as possible, the soil samples were taken at random it may be noted here that it was not possible to observe random sampling method while collecting samples from ant hills and earthen mounds. Four samples were taken from each mound thus twentyfour samples from six ant hills and sixtyfour samples from sixteen earthen mounds were collected Further each mound was divided into four halves—lighted top lighted base

shaded top and shaded base respectively ; one sample from each section was taken amounting to four samples per mound. The number of replicates was determined by the size of the sampling plots. The total number of soil samples collected from various plots was 132. Notes were taken on the vegetation specially around the earthen mound on l ant hills.

The soil samples taken were numbered and serially ar a ged in trays. In laboratory they were dried under room c nd ti s. The dried samples were broken carefully and sieved through a fel mesh w e g t pe to find eggpods. The egg-pods w re counted wa hed a d identified.

OBSERVATIONS

(A) *B el gi al rate*

An attempt was made to obs rve th repr luctive and the behaviour pattern of *C. parall l s* and *C. l x ra* in the field but it is form at ly n al ing much substantial at ac mplish d. These n t l ppers a e f ly mall in size and blend very w ll with their surr u d ngs n ler bl amount of patience and training of eyes are r q ired t n g t t em mati g or e laying. Frequentl fem les were seen l king n tu on th l are l bed or on mounds. Males were heard stridulatin f r ne t f th e l y. On seven occasions opulating pa s were seen. O s as re t th q lasted last for nearly 30 mins. The copulation postur may be d c be l as fa se male vertical position. The courtship beha iou w n t t d e l m det ll stroking by ant nn e s very characteris tic behav o ral pattern exh b t d by approaching males. Rarely ovipositing f males w re l served in the field. It takes 30-40 m n s to complete deposit n of eggs. The posture att ined by the ovipositing females is typ cal of acrid d. The att nd n mal s we e never seen near or rid ng on the ovipo t n f males which is freque tly observed in several locusts and oth r g ass ppers spec es. Both sex es exhibits closing operation of the ovip o t on h l after e g d pos t on by shovel ng soil with their hind legs. Nothin m ll a d defi tely e d ing the time of th day when oviposition t all takes pla e as no o posi ting females were observed in large scal

(B) *Egg-pods sam li g data*

The sampling results a tab lated T l l I. In l t l 1 and 53 egg-pods f *C. paral e* n l *C. l ra* r we a ned. Th t t l number of egg pods of *C.* r were f un l in th e l m t f wl *C. para lelus* n arly la d eq al amo nt f egg p in a t l l r tl en mounds. A very low number of e g l w r f d t l l t. Only 4 egg-pod of *C. parall* were obtained from the ...

(C) *Analysis of results*

The sampl ng data are summarized i Ta l 1. O t f 13 w l samples taken 21 and 53 egg-pods *C. parall* and *C. lra* r were o r

tained. The highest number of egg pods (about 78%) of *C. brunneus* were found in the earthen mounds while *C. parallelus* nearly laid equal amount of egg pods in ant hills and earthen mounds respectively. Only 4 egg pods of *C. parallelus* were obtained from the artificial semi bare plots. Few egg-pods were found in the heated bed.

The distribution of egg-pods of both species in ant hills and earthen mound is represented in Table 2. The egg-pods of *C. brunneus* were found in the proportion of 83·6% and 16·4% in top and lower halves of ant hills and earthen mounds. Similar figures 26·4% and 73·6% were recorded for *C. parallelus*. The data indicate that *C. brunneus* has shown a strong preference to deposit bulk of egg-pods in the well lit parts of the earthen mounds and ant hills where the surface soil is expected to be warm while *C. parallelus* has laid bulk of egg pods in lower shaded half in both types of mounds.

Further to disclose the relationship which may exist between laying and the topography of mounds, nature of mounds etc. the data were subjected to statistical tests. The number and frequency of egg pods of both species found in earthen mounds are shown in Table 3. The full analysis is shown in Table 4. The following inferences may be drawn.

1.—Total number of egg pods laid by *C. brunneus* is significantly greater than that of *C. parallelus*.

2. The significant interaction between position x species shows that the two species have different preferences of the position for oviposition. In this case, *C. brunneus* has a preference to lay more egg pods at the top while *C. parallelus* has preference to lay more eggs at the bottom.

3. Total number of egg-pods laid at top by both the species combined is not statistically different from the total number of egg pods laid at the bottom.

4. There is no significant difference in the total number of eggs laid between mound to mound.

Similar tests were carried out on ovipositional data in ant hills by both the species; but no significant interactions could be found hence the details of the statistical tests are omitted here.

Discussion

Previous workers (Waloff 1949, Richards & Walloff 1954) have observed that *C. parallelus* and *C. brunneus* deposit their egg pods in bare patches or in ant hills. Choudhuri (1958) has studied in cage experiments the soil factors which influence the choice of oviposition sit in these insects. The field results indicate that *C. parallelus* prefer to lay egg pods in ant-hills

whereas *C. brunneus* deposited large number of egg-pods in earthen mounds. Further the egg-pods of *C. brunneus* were distributed in the proportion of 71·4 and 12·2 in the top well lit and the lower half of the mounds. Similar figures 10·6% and 36·8 were recorded for *C. parallelus*. The preference indicated here can be explained in terms of the laboratory findings on the oviposition of these grasshoppers. Choudhuri (1958) has shown that *C. brunneus* prefer to deposit egg pod in soil which is compact and fairly dry while *C. parallelus* oviposit freely in soil which is moist and somewhat loose.

Besides the soil factors the temperature of soil is supposed to influence the selection of egg laying sites (Criddle 1933, Rubtzov 1935, Znamenskii 1951 and Choudhuri 1958 b). In present study low number of egg-pods found in the heated bed may be due to the fact that the soil temperature was much higher than the surrounding areas and perhaps on account of higher temperature gravid females did not prefer it. The moisture content of the soil in the heated bed and its structure might have been also effected by continuous heating. However in cage experiments Choudhuri (1958) has shown that *C. brunneus* prefers warm soil for oviposition as compared to *C. parallelus*. The fact is supported by the field experiment which shows that *C. brunneus* and *C. parallelus* both have laid 83·4 and 76·4 % of egg-pods in the top well lit areola of the mounds and ant hills where obviously the temperature of soil will be higher.

The soil reaction data in relation to oviposition preference in cage experiments did not reveal any significant results (Choudhuri 1958) and consequently no field experiment were designed to confirm this under natural conditions. The pH of soil in natural habitat of these grasshoppers in Silwood Park is fairly uniform showing slight acidic soil. In nature the acidity and alkalinity of soil does not seem to influence the selection of oviposition sites both the species occur on chalk hills and sandy heaths freely.

SUMMARY

1. The vegetation of the habitat of *C. parallelus* and *C. brunneus* is described.

2. Observations on the reproductive behaviour of *C. parallelus* and *C. brunneus* are recorded.

3. Field experiments were carried out to disclose whether *C. parallelus* exhibit any preference for their oviposition sites.

4. *C. brunneus* showed preference to lay egg-pods in earthen mounds while *C. parallelus* laid nearly equal amount of egg-pods in [illegible] and earthen mounds.

5. *C. brunneus* indicate strong preference to lay egg-pods [illegible] parts of the mounds (earthen mounds and ant hills) [illegible]

has laid most egg-pods in the lower parts of the mounds. A possible explanation for this preference has been suggested.

6. No egg-pods were found in the samples taken from turf artificial and natural bare patches.

7. The "heated bed" was not found suitable for oviposition. The possible explanation has been suggested.

8. The pH of soil from the study-area is fairly uniform. It does not seems to influence the choice of oviposition site in *C. parallelus* and *C. brunneus*.

Acknowledgements

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TABLE 1

Th[illegible] number of [illegible] found in d[illegible] [illegible]

(S[illegible] [illegible])

Sl. No.	S[illegible]	Are[illegible] S[illegible] plot	N[illegible] of [illegible]	Total n[illegible] of samples [illegible]	Number of [illegible]: C. [illegible]	Number of [illegible]: C. [illegible]
1	Heat d be[illegible]	5 sq ft	1 sample/ [illegible] ft	6	1	4
	Bare plot (art[illegible])	15 [illegible] ft	1 [illegible] [illegible] ft	9	0	0
3	Semi bare plot ([illegible])	15 sq ft	1 [illegible] sq f	9	4	0
4	[illegible] ([illegible])	1 5 sq ft	1 [illegible] ft	1	0	0
5	T[illegible]	41 sq ft	1 [illegible] sq f		0	0
6	[illegible]	5 [illegible]	[illegible]	1	10	8
7	Lat[illegible] ([illegible])	5 [illegible]	4 [illegible]	61	9	41
	T[illegible]	121 5 sq f		133	4	33

TABLE [illegible]

The d[illegible] [illegible] [illegible] [illegible]

S[illegible]	[illegible]: T[illegible]	[illegible]: Bare	[illegible]: Top	[illegible]: [illegible]	Total
[illegible]	5 (15 [illegible])	(5[illegible])	(10 [illegible])	[illegible]	19
C. [illegible]	[illegible]	[illegible]	[illegible]	6 [illegible]	13
T[illegible]	[illegible]	[illegible]	3	13	[illegible]

TABLE 3

Frequency distribution of egg-pods of C. parallelus and C. brunneus collected from earthen mounds

(Distribution of samples Top: Base :2 : 2 4 samples per mounds)

Levels of sampling sites	Total number of samples	Species	Frequency distribution																Total
			M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16	
Top	32	*C. parallelus*	0 0	0 0	0 0	1 0	0 0	0 0	0 1	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	2
		C. brunneus	0 0	0 0	3 0	0 0	0 6	0 0	9 0	6 0	0 0	0 0	0 3	4 0	4 0	0 0	0 0	0 0	35
Base	32	*C. parallelus*	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	2 0	0 0	3 0	0 2	0 0	0 0	7
		C. brunneus	0 0	0 0	0,2	0 0	0 0	0 0	0 0	1 0	0 0	0 0	0 0	0 0	0 0	0 1	1 1	0 0	6
		Total	0	0	5	1	6	0	10	7	0	0	5	4	7	3	2	0	50

M1—M16 denotes 16 artificially mad earthen mounds.

TABLE 4

[illegible] the square root transformation of the [illegible] data (number of [illegible] by [illegible])

Sl. No.	[illegible]	Degrees of [illegible]	[illegible]	M[illegible]	[illegible]	F (Expected [illegible] 1.5%)
1	[illegible]	15	2 0 [illegible]	1331	[illegible]	—
	Between T[illegible]	1	0 1135	1135	2 (0 n.s.	4 54
3	F[illegible] (1)	15	3185	16 [illegible]		
4	[illegible]	1	0 [illegible] 0		[illegible]	3 914
5	[illegible]	1	0 8[illegible]	[illegible]	4 0	3 914
[illegible]	[illegible]	[illegible]	17 14 [illegible]	[illegible]		
	[illegible]	1	[illegible]			

[illegible]



Fig. 1 Photograph showing the general appearance of the stud area

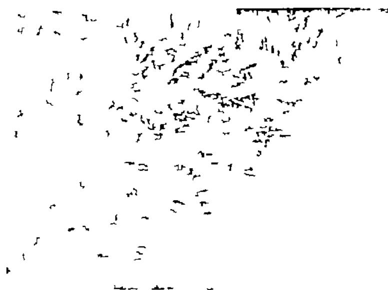


Fig 2 Th b



Fig. 1 Photograph showing the general appearance of the study area.



Fig. 2 The bare plot in the study area.



Fig. 5. The artificial mound in the study area.

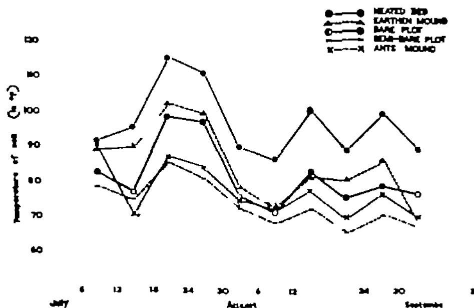


FIG. 6 TEMPERATURE (MEAN OF SIX DAYS) OF SOIL IN THE EXPERIMENTAL PLOTS

ON THE DIGESTIVE TRACT AND THE FEEDING HABITS OF SOME TELEOSTEAN FISHES

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The digestive organs are generally said to be correlated with the nature of the food and feeding habits of the animals. Various adaptational features have been reported in this connection in fishes by Suyehiro (1942) Al-Hussaini (1946, 1949) Mookerji and Das (1946) Pillay (1951 1953) Bapat and Bal (1952) and Das and Moitra (1955) Food and feeding habits of certain fishes have been studied by Moore (1941) Hartley (1948) and Hynes (1950) Recently Khanna (1961) examined the alimentary canal of several species of teleosts and discussed various interesting features found in them. The present paper deals with the structure of the buccopharynx and the alimentary canal of some fishes together with their feeding habits.

MATERIAL AND METHOD

The following fishes were examined in the course of this study:

	Type	*Family*	*Habitat*
1	*Tor* (*Barbus*) *tor* (Ham.)	Cyprinidae	Naini Tal Sat Tal, Naukuchia Tal Bhim Tal, Khurpa Tal, Gola River
2.	*Barbus tor* (Gunther)	"	Naini Tal, Bhim Tal Naukuchia Tal Khurpa Tal etc.
3	*Oreinus sinuatus* (Gunther)	"	Naini Tal, Bhim Tal, Nan kuchia Tal, Ramgarh, Khurpa Tal
4	*Nemachilus rupecola* (Hora)	Cobitida	Bhowali, Gola river Rati Ghat, Ramgarh.
5	*Mystus seenghala* (Skyes)	Siluridae	Ganga river

The above fishes were collected at frequently as possible from various sources mentioned above. The structure of the buccopharyngeal region was studied by cutting horizontal and vertical longitudinal sections of the head of the fish. Dissections were made to examine the alimentary canal and other structures associated with t. Microtome sections were cut and stained in Eosin and Haematoxylin to verify certai points. The gut contents were preserved in five per cent formalin and the percentage composition of various food items was worked out according to Hynes method (1950)

THE ALIMENTARY CANAL OF TOR TOR (Ham)

(Pl. I Figs. 1, 2, and 3 Pl. III Fig. 5)

The alimentary canal of *Tor tor* is a moderately long tube and consists of the buccopharynx, the oesophagus, the intestinal bulb, the intestine and the rectum. The mouth is a wide crescentic aperture situated at the anterior end of the snout and is bounded by the upper and the lower lips. The jaws and the buccal cavity are edentulous. A membranous fold of the mucous membrane called the velum or the maxillary valve lies behind the upper lip but the corresponding mandibular valve is absent. The buccal cavity is spacious and is lined with folded mucous membrane. A well defined tongue is not present in this species.

The pharynx is divisible into two parts—(a) The anterior part is respiratory in function and contains the gill arches. (b) The posterior part is masticatory in function. The ventro-lateral wall of the anterior pharynx is perforated by oblique gill slits and is supported by four pairs of branchial arches, each of which bears the gill lamellae on the outer side and the gill rakers on the inner side. The gill rakers are small stumpy outgrowths and are arranged in two rows on each arch, being relatively longer on the first than on the other arches. They are so arranged as to form the broad sieve-like structure across the gill slits, thus preventing the escape of the larger particles of food that come along with the respiratory water current. The roof of the pharynx in this region, is lined by fairly thick mucous membrane forming a cushion pad called the pharyngeal pad. A large number of papillae are present in this region and are gustatory in function.

The cavity of the pharynx narrows posteriorly where the masticatory apparatus is situated. This is a highly specialised part of the pharynx con[illegible] the fifth pair of gill arch. Gill lamellae are absent but a row of minute rakers is present on the arch. Further, it is raised upward in its hinder [illegible] approximate the dorsal surface and thereby reduces the pharyngeal [illegible] a small vestibule. A hard and oval callous pad is born by the [illegible] and several prominent teeth borne by the ceratobranchial of [illegible] branchial arch and known as the inferior pharyngeal teeth are [illegible] in the soft tissue on the ventral side of the vestibule. The teeth [illegible] conical structures being arranged in three rows and work [illegible] the dorsal callous pad, thus forming an efficient masticatory apparatus.

The oesophagus [illegible] a short narrow tube and is followed by the intestine [illegible] The first part of the intestine [illegible] wider and has a thicker wall [illegible] known as the intestinal bulb [illegible] large arm [illegible] It serves for the temporary storage of food and

is followed by the intestine proper which is narrow and coils round the proximal wider part. The intestine narrows gradually towards the posterior end and finally opens out by the anus The last part of the intestine is regarded as the rectum but is not distinguishable externally

The mucous lining of the oesophagus is longitudinally folded The folds become prominent and zig zag in the intestinal bulb but are less distinct posteriorly The liver is a large bilobed gland covering the alimentary canal from dorsal and ventral sides. The gall-bladder is a large sac situated between the right lobe of the liver and the coils of the intestine. The bile duct opens a little behind the oesophagus The spleen consists of several dark reddish lobes scattered in between the liver and the intestine The pancreas is diffused inside the liver thus forming the hepato-pancreas and also occurs in the adipose tissue of the body cavity

THE ALIMENTARY CANAL OF BARBUS TICTO (Gunther)

(Pl II Fig 2)

The alimentary canal of *Barbus ticto* is a long tube resembling closely with that of *Tor tor* and comprises of the buccopharynx the oesophagus the intestinal bulb the intestine and the rectum.

The mouth is a medium sized aperture at the anterior end of the snout. The jaws and the buccal cavity are devoid of teeth. A maxillary valve is present. The pharynx, like that of *T tor* is divisible into an anterior respiratory part and a posterior masticatory part. The gill rakers are minute and form a filtering apparatus. A cushiony pad is present in the roof of the branchial region of the pharynx and a masticatory apparatus consisting of a dorsal callous pad and ventral teeth is present in the posterior pharynx.

The oesophagus is a short tube and leads into the intestinal bulb a true stomach being absent in this species also The intestine, however is relatively longer than in the case of *T tor* and is two to three times the length of the fish. The rectum can be identified with the help of internal folds only The mucosal lining of the intestinal bulb is papillated. A well developed hepatopancreas is present, pancreas being diffused into the liver Spleen lies embedded in between the lobes of the liver

THE ALIMENTARY CANAL OF OREINUS SINUATUS (Gunther)

(Pl II Figs 1 and 3)

The alimentary canal of *Oreinus sinuatus* is also similar to that of *T tor* and *B tict* described above and consists of the same regions The mouth is a small transverse slit situated sub-terminally on the ventral side of the snout. The lips form a suctorial disc, by means of which the fish attaches itself to stones or *other objects in the water The lower lip is hard and* broad. The jaws and the buccal cavity are edentulous and a maxillary

valve is present behind the upper lip. The buccopharyngeal cavity is narrow at the anterior and posterior ends but is wider in the middle. The mucous membrane lining the buccal cavity shows longitudinal folds in the roof and transverse folds in the floor.

The pharynx consists of an anterior respiratory part and a posterior masticatory part. The branchial arches bear the gill lamellae and the gill rakers which latter are minute, soft and less prominent. Thus the filtering mechanism is not so well developed and so efficient as it is in the case of *Tor tor*. A cushion pad is present in the roof and bears gustatory and mucous secreting papillae. The posterior pharynx is in the form of a vestibule containing a hard callous pad borne by the basioccipital on the dorsal side and inferior pharyngeal teeth on the ventral side. The callous pad is a distinct structure but less developed in this species and bears two rounded protuberances on it. The wall of the vestibule is covered with soft and papillated mucous membrane. As the food passes through this region, it is crushed by the masticatory apparatus and gets mixed up with a large amount of mucus secreted by the mucous cells of the lateral and ventral walls of the vestibule.

The oesophagus is a short tube. A true stomach is not present. The intestine is comparatively longer than that of *T. tor* and *B. tida* and is coiled into several loops. The food is stored temporarily in the intestinal bulb. The rectum is not differentiated externally. Prominent mucosal folds are present in the [illegible] (parallel) and the intestinal bulb (zig zag) but are [illegible] posteriorly. There is no valve to separate the intestine from the intestinal bulb.

The liver is a [illegible] lobed, the left one being very small. [illegible] subdivided into smaller ones and are joined at the anterior end and [illegible]. The gall bladder is sac like. The bile duct opens [illegible]. The pancreas is a diffused gland lying scattered [illegible] the liver and in the [illegible] of the body cavity.

THE ALIMENTARY CANAL OF NEMACHILUS RUPICOLA (HORA)
Pl. III Fig. 1 and 2; Pl. II Fig. 4)

The [illegible] of N. [illegible] is a short tube and consists of [illegible] the stomach, the intestine and the rectum. The [illegible] position. The [illegible] There is no trace of [illegible] teeth in the buccal cavity. Membranous [illegible] is present. A [illegible] formed by [illegible] the fish in adhering to stones etc. [illegible]

The buccal cavity narrows posteriorly and the *pharynx* is divisible into two parts the anterior one contains the gills and is respiratory in function and the posterior one contains a simplified masticatory apparatus. The branchial arches bear the gill *lamellae on the outside and small, stumpy soft* gill rakers towards the inner side. The gill rakers of the neighbouring arches interdigitate and form a broad sieve like structure A cushiony or pharyngeal pad is not found in this species though the mucous membrane is thicker in the roof of the pharynx than elsewhere.

The posterior part of the pharynx is narrow and forms a vestibule in which a soft muscular pad is present in place of the callous pad found in the other teleosts described earlier The corresponding part in the floor is soft and papillated in which are embedded a few minute teeth the inferior pharyngeal teeth visible only under a lens The inferior pharyngeal teeth work against the rudimentary dorsal muscular pad *forming a primitive type of* masticatory apparatus

The oesophagus is a short tube and is followed by the stomach which is U-shaped and consists of a *narrow* cardiac and *pyloric limbs* and a *wider* fundus. The stomach narrows considerably at the pylorus and is followed by the intestine which at first runs parallel to the left limb of the stomach and then turns posteriorly The intestine is short and is not much coiled as in other cases. Its anterior portion is wider and may be called the duodenum. The intestine narrows posteriorly and opens to the exterior by the anus, the last part of it being considered the rectum. Prominent longitudinal folds are present in the oesophagus and stomach while in the duodenum and the intestine they are more or less zig zag in arrangement. In the rectum the folds are again longitudinal but less distinct.

The liver is a well developed bilobed gland and completely covers the cardiac region of the stomach. The bile duct opens a little ahead of the pylorus. The spleen consists of one or two dark reddish brown lobes and the pancreas is diffused in the body cavity

THE ALIMENTARY CANAL OF MYSTUS SEENGHALA (Sykes)

(Pl III Figs. 3 and 4)

The alimentary canal of *Mystus seenghala* is comparatively a short tube and *consists of* the same parts as *described in the case of R. rapsela.* The mouth is a wide transverse slit at the anterior end of the snout. The buccal cavity is spacious and relatively longer than in the other fishes described above. The roof of the buccal cavity is furnished with numerous minute and pointed teeth present on the premaxillae and the vomers Corresponding to the premaxillary teeth, mandibular *teeth are also present on the dentary* All these teeth are meant to prevent the escape of the prey and are not used for biting or chewing. Both the maxillary and mandibular valves are present. The tongue is not prominent in this species

The pharynx is not so clearly differentiable into two parts as in other teleosts described above. Its ventro-lateral wall is perforated by gill slits and the first four pairs of gill arches bear the gill lamellae and the gill rakers. Here the gill rakers are long, hard and pointed structures and are arranged in one row on the first, the second and the fifth arches and in two rows on the third and the fourth pairs of arches. They are longest on the first and shortest on the fifth gill arch and form a broad sieve like structure preventing the escape of larger particles of food. Moreover, the gill rakers along with the various types of teeth of the bucco-pharyngeal region of the fish serve to macerate the prey.

The mucous membrane between the gill arches is papillated. In the [illegible] part of the pharynx two hard bony plates bearing the superior pharyngeal teeth are present on the dorsal side and are borne by the fifth pair of pharyngobranchials. Corresponding to these are present the inferior pharyngeal teeth on the ventral side and are borne by the fifth pair of [illegible]. The teeth like those of the upper and the lower jaw are [illegible] and differ [illegible] from those of the other teleosts described [illegible]. They [illegible] not used for mastication of food and merely serve to prevent the [illegible] of the prey when once it is taken into the pharynx. [illegible] prey [illegible] adequate maceration also due to the presence of these pharyngeal teeth.

The [illegible] the posterior end of the pharynx between the [illegible] teeth and [illegible] into [illegible] followed by a true stomach [illegible] into two parts [illegible]. The anterior narrow cardiac portion [illegible] fundus and (b) the [illegible] tal narr[illegible] portion. The [illegible] for a temporary storage of food [illegible]. The intestine is relatively short and extends from the pyloric [illegible] stomach for a short distance [illegible]. The intestine hardly makes [illegible] anterior part is a little wider than the rest. This [illegible]. The rectum is not differentiable [illegible].

[illegible] of mucous cells are present in the oesophageal [illegible] are found in the posterior part [illegible] the bile duct [illegible] between [illegible] of the liver. The [illegible] brown colour.

Food of Heteropneustes

The [illegible] were carefully examined [illegible]. A large number of [illegible] to December [illegible]

The average percentage compositions of the food of these species is given in table no. I The analysis shows that *Tor tor* usually feeds on the plant material such as *multicellular* algae and vegetative parts of the higher aquatic plants. The food also includes a fair amount of insects which were represented by their exoskeleton and appendages in the gut. Rarely cycloid scales of small fishes were also present. It so appears that this fish swallows all type of food material that comes along with the water current and is as such omnivorous in habit

The gut contents of *Barbus ticto* reveal that this species takes unicellular and multicellulae algae, higher plants, insects larvae and crustaceans. Thus it is also an omnivorous fish. *Oreinus sinuatus* is a herbivorous fish and feeds on multicellular algae and other plant materials and a fair amount of mud is also found inside the gut of th s fi-h

The exam nation of the gut contents of *Nemachilus rupicola* shows that it feeds mainly on insects and crustaceans whose exoskeletal parts and legs were found in the stomach Mult cellular algae were found in a few isolated cases and do not form the regular food of this fish, which is an insectivorous one.

The food of *Mystus seenghal* includes crustaceans, insects, insect larvae and fishes In many cases the food consisted of fish material only This species is predominantly carnivorous and predatory in habit.

DISCUSSION

The present study has revealed the number of interesting features of the digestive tract of teleosts and many of them can be explained as adaptations due to differences in their feeding habits The mouth is a wide aperture providing a large gape to the fish n the carnivorous species *Mystus seenghala* but is narrow in the harb vorous forms and is subterminal in a predominantly herbivorous bottom feeder the *Oreinus sinuatus*

Numerous teeth are present on the jaws and in the pharynx of *M seen ghala* to help this fish in catching the prey and preventing its escape. Moreover the gill rakers are also spiny and assist the teeth in the discharge of their function. They are n t of masticatory nature as the prey is swallowed and is not crushed in the pharynx. Such a specialised bucco-pharynx is evidently a characteristic feature of a carnivorous species and is very much suited to its feeding habits.

An insectivorous fish like the *Nemachilus rupicola* is not in need of such a specialised dentition and shows a lesser development of teeth and gill rakers. Jaws are edentulous and only minute inferio pharyngeal teeth are present. A muscular pad s situated in place of the superior pharyngeal teeth and forms a primitive type of crushi g apparatus.

T tor is an omnivorous fish feedi g upon micro-vegetation insects and filamentous algae Teeth are entirely absent from the jaws and the palate i

TABLE I

Showing area percentage composition of food

No.	Name of the Fish	Unicellular Algae	[illegible]	Higher Plants	[illegible]	Crustaceans	Worms	Fish	Mud	[illegible]
1	*Tor tor*		5	30	20	10	2	1.5	1	5.5
	[illegible]	10	[illegible]	10	35	10			5	10
3	*[illegible]*		15	3	..		1		60?	5
4	*[illegible]*			5	45	1	2			15
5	*[illegible]*				15	[illegible]		45	..	20

[illegible] ... is a filtering apparatus formed by the gill rakers which are small ... with ... other forming a kind of ... structure to prevent the escape of the food through the gill slits. The posterior part of the pharynx is greatly modified in this fish for crushing the food. This portion is very narrow and is armed with a dorsal callous pad and ... pharyngeal teeth forming an efficient masticatory apparatus. This is a special adaptation for the food taken in by this fish and compensates the absence of teeth from the jaws.

[illegible] ... is a predominantly ... The suctorial disc ... is a device for securing firm attachment ... The buccopharynx with a filtering mechanism ... of *Tor tor*. The teeth and the ... very much related to the nature of the food.

[illegible] ... paper *[illegible]* ... possesses the longest ... *Tor tor* ... gut ... (Khanna 1961).

[illegible] ... present ... the ...

that the absence of stomach in these fishes is a specialized feature and that they have somehow dispensed with the gastric digestion.

The pylorus is absent in the stomachless fishes and the pyloric caeca are not present in the species described in this paper Rectum is also not differentiable externally and the alimentary canal is generally a simple one.

The pancreas is not visible as a campact gland as is found in the higher vertebrates except in *M seenghala* and is diffused into the liver and in the adipose tissue of the body cav ty

SUMMARY

1 Structure of the buccopharynx and the alimentary canal of five species of teleostean fishes has been studied along with their gut contents

2 The gut contents were analysed to establish carnivorous herbivorous, omnivorous and insectivo ous species

3 Various structures in the buccopharynx such as the position of the mouth, teeth gill rakers masticatory apparatus etc are closely related to the nature of the diet of these fishes

4. The carnivorous species shows a specialised dentition and large and pointed gill rakers. Teeth are not masticatory

5 Teeth are absent in the herbivorous and omnivorous species but they possess a well formed masticatory apparatus in the posterior part of the pharynx and a filtering device is formed by the gill rakers.

6. *Nemachilus rupicola*, an insectivorous fish, has a primitive type of crushing apparatus.

7 The length of the alimentary canal generally depends upon the type of food being longest in the herbivorous and shortest in the carnivorous forms.

8 A true stomach is present in *M seenghala* and *N rupicola* only and is absent in *T tor B tictu* and *O sunatus* An intestinal bulb is present in these species and this is probably a specialised feature

9 The pylorus is absent in fishes devoid of stomach and the pyloric caeca are absent from these species

10 Rectum is not distinguishable externally and an ileorectal valve is not present.

11 Pancreas is a compact gland in *M seenghala* but diffused in others

ACKNOWLEDGEMENT

It is a great pleasure to acknowledge the facilities provided to us by Dr S P Bhatnagar Professor of Zoology Th. D S B Govt. College, Naini Tal during the course of this work.

PLATE I

FIG.1

FIG.2

FIG.3

Fig. 1 Horizontal Section of th head of *Tor tor* showing the pper half of the buccopharynx ... x 0.8

Fig. 2 Horizontal section of the head of *Tor tor* showing the lower half of the buc opharynx x 0.8

Fig. 3 Median longi udinal section of the head of *Tor tor* ... x 0.8

PLATE II

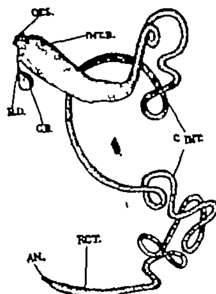


FIG.1

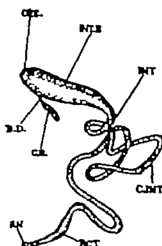


FIG.2



FIG 4

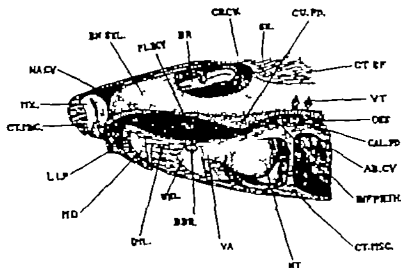
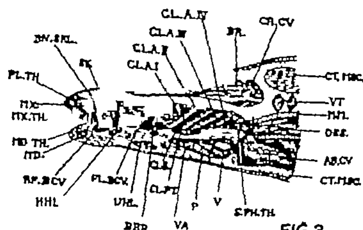
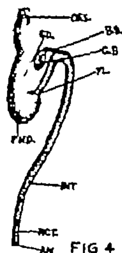


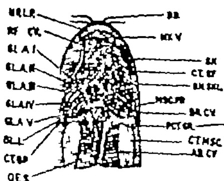
FIG.3

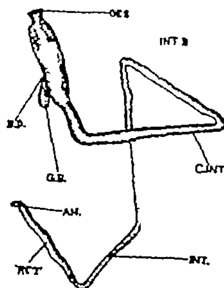
Fig. 1 Alimentary canal of *Oreinus sinuatus* uncoiled — x 0 7
Fig 2. Alimentary canal of *Barbus ticto* uncoiled x 5
Fig 3. Median longitudinal section of the head of *Oreinus sinuatus* — x 2
Fig 4. Alimentary canal of *Nemacheilus rupicola* — x 1

PLATE III









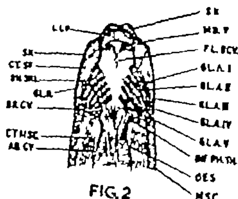


Fig. 1. Horizontal section of the head of *[illegible]* showing the upper half of the buccopharynx. 1.5

Fig. 2. Same as above showing the lower half of the buccopharynx 1.5

Fig. 3. Median longitudinal section of the head of *My. seenghala* 1.3

Fig. 4. Alimentary canal of *M. seenghala* uncoiled 0.7

ECONOMICS OF CROPPING PATTERN IN DISTRICTS OF EASTERN UTTAR PRADESH

J S GARG*

SELECTION OF HOLDINGS

With a view to know the economics of cropping patterns studies were conducted in five districts, *viz.* Ghazipur Azamgarh, Jaunpur Varanasi and Ballia of Eastern U P by the post-graduate students of Agricultural Economics, at the Government Agricultural College Kanpur under the guidance of the writer during the years 1960-61 and 1961-62. The paper is a summary of their research findings.

The study is based on 860 holdings, selected through random sampling method. 800 holdings were selected from the two size-groups upto 5 acres and above 5 acres, in Azamgarh, Jaunpur Ghazipur and Varanasi districts. Besides, 60 holdings were selected from 5 villages of one block in Ballia district. There were six size-groups, varying from below 2 5 acres to above 15 acres Fo the purpose of calculations these holdings were also grouped into the above two size-groups, *i e.*, upto five and above 5 acres. In all there were 85 villages selected through random sampling method from 9 Development Blocks in five districts which were selected purposively representing the Socio-economic conditions prevailing in the districts. Districts were also selected purposively keeping in view the convenience of the investigators. The data was collected by the survey method on prescribed schedules, through personal interviews

CHARACTERISTICS OF THE REGION

The Eastern Region of Uttar Pradesh is characterised by high density of population (being 844 per square mile as against 557 for the whole State and 287 for the country) low output per capita and extremely scanty resources. The soil has low fertility though it is n t basically defective. Rainfall is erratic, and *is unequally distributed. Floods and drought are the common* features of this region. Often long breaks in rain create drought and heavy downpours bring in floods and consequently the region is called a Scarcity Area The yield per acre is comparatively low and the per cap ta natural resources are poor The extent of rural to the total population varies from 73 7 per cent in Ballia to 93 per cent in Deoria Under this pressure eve the marginal and sub-marginal lands have been brought under cultivation. The proportion of the net area sown to the cultivated area varies from 80% to 92% in Ballia. The average size of holding below 5 acre size group under study is 2·83 acres against the average of about 4 acres of all the holdings numbering 10 millions in the entire State. 81·2 of the total holding n the State are below 5 acres.

Garg, J. S. Production Economist Cum-Prof., Govt. Agric. College Ka pur U.P (India

Cropping Pattern

The table given below shows the percentage distribution of cropped area on the holdings under study

TABLE 1

Showing the percentage distribution of cropped to total area under cultivation

Districts	Paddy	Barley	Sugar can	Wheat	Gram	Pea	Bajra Sawan or Arhar	Maize
Ballia	42 60	23 00	9 72	5 30	4 66	13 53	...	
Ghazipur	24 48	...	2 5	6 15	5 3		5 4	...
Jaunpur	14 21	24 29	6 01	14 18	...	...	...	22 8
Azamgarh	49 56	15 59	6 15	4 47	4 38	9 04	...	...
Varanasi	35 81	9 24	5 23	5 62	4 39	4 8	5 3	3 8
Average of all holdings	33 00	18 00	8 00	6 75	5 00	8 55	5 4	22 8

It is clear from the table above that paddy in Kharif and Wheat and Sugarcane in Rabi are invariably grown in all the districts under study Single cropping is the common pattern of farming of this region On an average, the area occupied by paddy alon is 33 % followed by maize 22.8% at Jaunpur and barley 18 % of the total cultivated area. Pea, sugarcane, wheat bajra and gram, on an average, occupy 8 55% 8·00%, 6·75%, 5 4% and 5% respectively of the cultivated area in a descending order The highest percentage of area under paddy is 49·56 in Azamgarh and those of maize, barley whet and sugarcane being 22 8 24·29 14 18 and 6·01 respectively in Jaunpur Barley in Ghazipur gram in Jaunpur and Ballia pea in Jaunpur and Ghazipur bajra in Ballia Azamgarh and Jaunpur and maize in Ghazipur Azamgarh and Varanasi are not commonly grown Barley wheat mustard, gram-barley maize urd Jowar-Sawan-Arhar wheat gram and gram-linseed are the common crop mixtures practiced in mixed cropping

Table 2 shows the percentage of the total cropped area occupied by food fodder and sugarcane—a major cash crop and the cropping intensity districtwise

TABLE 2

Percentage of total cropped area occupied by food fodder and sugarcane of the total cultivated area and percentage of cropping intensity districtwise

Districts	Food crops	Fodder crops	Sugarcane	Cropping Intensity percentage
Ballia	85 63	5 27	8 90	113 38
Ghazipur	91 63	3 06	2 35	122 00
Jaunpur	86 92	2 00	6 00	127 28
Azamgarh	90 00	1 90	6 10	117 75
Varanasi	82 92	7 43	5 23	148 48
Average of all holdings	87 45	3 95	5 76	125·96

It is clear from the above table that on an average, the percentage of the total cropped area occupied by food and fodder is 91·41 and that under sugarcane 5 76. Remaining 2 83% might be in other crops which are not taken into consideration in the study Sugarcane is the major cash crop of the region The percentage of intensity of cropping is 125·96. The figures show that the economic situation of this region is very alarming, as the ratio between cash and other crops is very wide. The cropping intensity at 125·96% is also an indication of the fact that the intensive practices of farming are not followed in this region. As such, there is much scope of modifying the cropping pattern in this region with the introduction of new crops in conformity with the demand.

Economic Studies

Average investment on fixed capital

The following table shows the average investment per holding and per acre in the selected districts. Value of land and residential buildings has not been included in the fixed capital The items included in the fixed capital are livestock, Deadstock and the godown for grains and implements and livestock shed

TABLE 3

Showing the value of investment in fixed capital

Investment	Ballia	Ghazipur	Jaunpur	Azamgarh	Varanasi
Rs.	Rs.	Rs.	Rs.	Rs.	Rs.
Per holding	1789 00	1673 00	1601·00	2478 00	1743 00
Per acre	225 00	225 00	244·00	302 00	243 00

The average investment per holding and per acre comes to Rs. 1956·00 and Rs. 247·80 respectively

Input-Output Ratio

Input, output, net profit or loss family labour Income, farm business income are given below district-wise in table 4

TABLE 4

Showing per acre value of Input, Output Net profit or loss, Family Labour Income and Farm Business Income (In Rupees)

District	Input	Output	Net profit	Family labour income	Farm business income	Ratio input/output
Ballia	174 00	188 70	14 70	69 11	78 39	1 1 1
Ghazipur	173 72	231 83	58 09	117 36	127 29	1 1 37
Jaunpur	177 00	247 94	70 64	10^ 06	113 18	1 1 40
Azamgarh	157·98	244 83	86 87	122 57	130 99	—1 1 55
Varanasi	184 21	242 83	58 62	96 09	106 38	1 1 34
Average for all holdings	173 39	231 22	57 92	101 44	111 22	1 1 33

The table given above indicates that the net profit per acre under study on all holdings on an average is Rs. 57·92, while Rs. 86·87 is the highest at

Azamgarh and the lowest Rs 14 70 in Ballia. The average input per acre is Rs. 173 39 and output Rs 231·22 The farmer in this locality on an average earns Rs 111 22 per acre as farm business income which includes the net profit of the business value of his family labour the interest on unpaid investment and the charges for the supervision and management etc.

The breakup of the percentage distribution of total value of input factorwise is given below It gives an idea of the proportionate expenditure incurred by a farmer on the various items of production on crop growing on a farm in the region.

TABLE 5

Percentage distribution of total value of input factorwise

District	Bullock labour	Human labour	Seed	Fertilizer	Upkeep of Implements.	Land revenue	Irrigation	Interest on working capital
Ballia	45 21	27 50	8 20	3 70	3 30	2 90	4 10	5 10
Ghazipur	41 81	38 40	8 05	2 55	1 18	3 45		4 56
Jaunpur	45 58	23 99	10 26	7 25	2 46	4 03		5 43
Azamgarh	40 70	32 64	9 98	6 60	3 35	1 86		5 33
Varanasi	51 81	30 00	8 62	9 13	2 02	2 36	2 64	6 41
Average of all holdings	45 03	30 50	8 8?	5 84	2 46	2 12	1 34	5 36

It is clear from the above table that bullock and human labour accounts for more than 75% of the total expenditure per acre on a farm. On account of seed and fertilizers, the input is hardly 14 68% The irrigation has hardly contributed 1 34 % which is almost negligible comparing the irrigated area of the locality under study The utilisation of fertilizers also appears to be very poor Heavy utilisation of human labour supports the fact that the improved implements leading to saving in labour and time are not much used It can be concluded from the table above that there is a much wider scope for improving the cropping pattern in the region

Table 5 is condensed from tables prepared separately to work out the cost of cultivation of the crops grown on a farm, factorwise.

The percentage value of family labour on average is 64 94% varying from 71 60% in Ghazipur to 58·00% in Ballia and that of hired labour 35·06 %

Output—It is clear from table 4 that on an average, on holdings under study the output per acre was Rs. 231 22 The percentage contribution to output by various crop enterprizes is given in table 6

TABLE 6

Percentage contribution to output by various crop enterprizes on the holdings under study

District	Paddy	Barley	Sugar cane	Wheat	Gram	Pea	Bajra or sawan & arhar	Maize
Ballia	37 54	16 52	19 1	5 98	2 56	5 29	6 5	
Ghazipur	31 20	15 70	5 52	5 15	4 50	8 15	10 50	—
J unpur	16 60	22 80	9 50	14 60	4 00	3 80	6 50	17 4
Azamgarh	35 93	18 78	19 25	6 88	87	5 47	6 86	—
Varanasi	34 55	9 45	15 80	4 40	2 55	3 00	5 00	
Average on all holdings.	31 08	16 61	13 77	7 55	3 21	5 51	7 00	17 4

It is clear from the table that the main contribution to output under study is from paddy followed by barley sugarcane and wheat crops They contribute about 67% of the total output The remaining 33% comes from the crops like pea gram, bajra or sawan and arhar (mixture) and other crops of minor importance like go-chana etc Maize contributes to the xtent of 17·4 of the total output in Jaunpur In all districts, except Jaunpur paddy is the highest contributing crop varying from 31 20% in Ghaz pur to 37 50% in Ballia. Sugarcane has substantially contributed in the income varying from 19·25% in district Azamgarh to 19·12 % in Ballia and 15 89% in Varanasi. Barley has contributed 22 80 % n Jaunpur 18 78% in Azam garh, 16·52 % in Ballia and 15 70 in Ghazipur of the total output of each district. Wheat and maize has contributed 14·60 and 17 40 % espectively to output of district Jaunpur The main contributing crops to the output in Ballia are paddy sugarcane and barley and those in Ghazipur paddy barley Go-chana (wheat and gram) bajra and arhar and pea in Jaunpur Barley maize, paddy and wheat in Azamga h paddy sugarcane ba ley wheat and sawan and arhar (mixture) and in Varanasi paddy sugarcane and barley

Return to investment

Table 7 shows the percentage return to capital in estment and the actually incurred cash and kind expenses.

TABLE 7

Showi g the percentag return to capital nvestment and actually incurred cash and kind expenses

Items	Ballia	Ghazipur	Jaunpu	Azamgarh	Varanasi	Average on all holdings
Percentage return to capital	4 80	5 45	8 70	7 34	6 05	3 17
Percentage of actually incurred cash & kind expenses	27 50	24 00	22 20	27 00	24·60	25 10

It is clear from table 7 that the percentage return to captital investment on an average is 5 17 it being the highest at 8·20 in Jaunpur and lowest at 4 80 in Ballia

The percentage actually incurred in cash and kind expenses for all the holdings is 25% This includes the expenses incurred in the purchase of seed, manure fertilizer and wages to hired labour and rent of land, if any and irrigation charges.

Conclusion

The study of the five districts of eastern U P based on 860 holdings reveals that the cropping pattern of this region is very poor and return per acre is very unsatisfactory The crop intensity is hardly 125% and the crops grown do not possess the high returning potential. The cropping pattern followed in this region is more or less of subsistance nature. The percentage of expenses on the consumption of fertilizers and irrigation charges are almost negligible, comparing the vastness of the area and irrigation facilities available.

Therefore, the immediate necessity is to introduce the modern technique of farming *e g* Japanese method for growing paddy and U P method for growing wheat. Extension of improved implements for the preparation of land and interculture operation in the field should be immediately taken. Application of fertillizers and use of irrigation facilities should be increased and the practices of sowing crops in lines be taken up. Double cropping programme should be planned with the introduction of new crops suiting to the situation of the locality

There is much scope for the introduction of potato and tori (oilseed crop) in this region, for the success of which marketing facilities will have to be developed and cold stores for the storage of potato will have to be established Such crops and the varieties thereof which can withstand the flood and drought conditions simultaneously will have to be introduced. Soil conservation practices will be put into operation to increase soil fertility

The salvation of this region lies in the improved cropping pattern which should be planned after thorough study of the physical conditions of the area and socio-economic condition of the farmers by the Agricultural Economist, Production Economist Agronomist, and Planners as a coordinated programme in a team pirit.

Acknowledgement

The author expresses his thanks to Sarvari Umashanker Singh, Paramatma Singh Kashi Prasad Pal Lacchi Ram Singh and Bansh Bahadur Singh for drawing upon some of their data which they submitted in their thesis for the M Sc. (Ag) Degree in Agricultural Economics from the Govt. Agricultural College Kanpu under the guidance of the author

SOME THEORETICAL AND APPLIED INVESTIGATIONS ON ELASTO-PLASTIC BEHAVIOUR OF ORTHOTROPIC AND NON HOMOGENEOUS MATERIALS

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Intense technological development in the recent past has resulted in the development and extensive use of plastics in the construction of equipment and structures on the one hand and on the other in the use of metals at elevated temperatures, for example, in oil refineries, gas turbine, high speed aeroplanes, missiles, satellites and in nuclear power generating equipment. The gross deformation behaviour of plastics and natural high polymers at room temperature is similar to that of metals at elevated temperatures. Application of a constant stress results in an instantaneous elastic strain followed by a strain which gradually increases with time The time-dependent strain is known as creep Similarly application of a constant strain results in a slow relaxation of stress Concrete is another example of a material which shows time-dependent mechanical behaviour

Theories of elasticity and plasticity do not take into account the influence of time for which the load acts or the body is deformed and are, therefore, totally inadequate for the analysis of stress or strain in materials showing time-dependent mechanical behaviour In fact, it has been shown by many investigators that under constant load the stress distribution can exhibit large changes with time if time-dependent mechanical behaviour is taken into consideration whereas, analysis according to elastic theory leads to the conclusion that stress distribution remains constant

Thus, the need of study of mechanical behaviour of materials and analysis of stress and strain taking time-effects into account is obvious. Such an analysis would necessarily lead to more rational design, permitting economy in use of material consistent with safety against failure.

For this purpose, theory of linear visco-elasticity has been developed by Simha[13] Alfrey[1] Bland and Lee[3] However most of the real materials show a non-linear strain stress relationship in their time-dependent mechanical behaviour Most of the non-linear problems have been attempted for stress analysis under constant loads on isotropic materials, notably by Odqvist[12] Hoff[10] and Marin [1] among others. But some actual materials show a further complication They are anisotropic, that is their mechanical properties are different in different directions. Examples of such materials are single crystals rolled or drawn metals, laminated or sandwich structures and biological products like wool, rubber various fibres and wood. Some of these materials, which have three mutually perpendicular axes of symmetry with regard to their

physical properties are said to be orthotropic. In cold rolled sheet, for example, the axes of symmetry would lie in the plane of rolling parallel and perpendicular to the rolling direction and along the normal to the sheet. A typical orthotropic material is wood.

Morever many of these materials show a linear strain-stress relationship below a limiting stress called 'limit of plastic flow' and a non linear relationship above it.

An attempt has been made to develop a suitable theoretical framework for study of the problem of stress analysis in orthotropic materials showing time-dependent mechanical behaviour and a limit of plastic flow. Solutions of some problems have also been obtained. In connection with these studies some applied investigations were also carried out to see how closely the basic creep equations can represent the creep test data in wood, to compare the predicted values of deflection on the basis of the theory proposed with those actually observed in experiment and lastly to study the creep behaviour of wood in bending and the effect of temperature, seasoning condition, stress level and species on the same. These investigations have been published in a number of papers [1-8]

The mechanical behaviour of wood in common with other elasto-plastic materials is sensitive to change of temperature and moisture content. It exhibits a complex time behaviour under constant load, wood responds with an instantaneous deformation, a time-dependent deformation which recovers on unloading and a time-dependent deformation which is not recoverable on unloading. Wood is a non-homogeneous material physical properties differ not only from species to species, but from tree to tree in the same species and also from specimen to specimen in the same tree. In a single specimen, the mechanical properties differ in the three orthogonal directions of symmetry the longitudinal, tangential and radial directions of the tree growth. For this reason wood is known as an orthotropic material. Since temperature and moisture content have an effect on the mechanical properties of wood tests must be carried out under constant conditions of temperature and moisture content if they are to yield reliable and useful data. Keeping temperature and moisture content constant is particularly necessary in case of long duration tests where the effect of changing conditions may completely obscure the property under observation. Since wood is a non-homogeneous material it requires careful matching and even then the values of constants derived show considerable difference from specimen to specimen. Anisotropy requires the mechanical testing to be with reference to the axes of anisotropy. If it is not so the principal axes of stress and strain do not coincide and it becomes complicated to interpret the test results physically.

Thus testing of wood is difficult, moreover creep tests are time consuming, this is perhaps the chief reason for scarcity of experimental data on

creep in wood. However creep tests are essential not only for the light they throw on the fundamental mechanical behaviour but also for use of the observations under actual service conditions, where the damaging effect of creep are reported to be (i) continually increasing deformation may eventually exceed permissible tolerances, (ii) a member becomes unstable and weak with excessive deformation, (iii) under prolonged loading many engineering materials including wood are known to fail at stresses much lesser than under standard short time test conditions. In design, allowance is made for each of the above damaging effects but precise knowledge of creep and the influence of temperature and moisture content on the same are required to be known for more rational design

The results of these theoretical and applied investigations are briefly described below

Available experimental evidence on creep behaviour of high polymers, particularly timber shows that the creep behaviour is characterized by two different regions of deformation and a limit of plastic flow (limiting stress above which *creep deformation is a non-linear function of stress*) Strain-stress-time relations of a general nature are proposed on the basis of the experimental evidence. There are two such relations one for the case when applied stress is less than the limit of plastic flow and the other for the case when applied stress is greater than the limit of plastic flow These relationships have been extended to the case of multiaxial state of stress in anisotropic materials even for the case of variable stress. A criterion for the application of second type of strain-stress-time relations called criterion of secondary creep has been adopted from Hill's development of von Mises yield criterion for anisotropic plastic theory Some general theorems between constants of strain-stress-time functions are also proved.

Application of the theory to some simple miscellaneous problems has been attempted. As an illustration of the method of stress and strain analysis where principal axes of stress do not coincide with the axes *of anisotropy* the problem of tension is solved *As a simple illustration* of the method of stress and strain analysis where stress may vary with time, *problem of* compression under conditio s of plain strain is attempted.

Analysis of stress distribution and deflection in the bending of beams has been attempted It has been shown that the stress distribution is a function of time, in case secondary creep criterion is satisfied. Effective solution connecting extreme fibre stress -with time for a beam of rectangular cross-section is obtained. Exact value of extreme fibre stress at any time can be obtained from the solution by numerical calculations on the basis of experimental constants. Graphical methods can then be used to give the extreme fib e stress as an explicit function of time. Based on such an expression, extreme fibre strain, radius of curvature and a differential equation for the determination of deflections have been derived. The

differential equation can be solved in specific cases if bending moment can be expressed as a function of the coordinate axis along the length of the beam. Two examples have been solved for deflections, as illustrations of the method.

Torsion of a solid cylindrical rod of circular cross-section is considered. Based on assumptions similar to those in the theory of elasticity regarding components of displacement it has been possible to obtain stress distribution and an expression connecting twist with the applied torque and time, when secondary creep criterion is not satisfied. But when the secondary creep criterion is satisfied, the stress distribution changes with time and the shape of primary-secondary creep interface cannot be determined. The problem has been simplified by assuming that mechanical properties in all directions in a transverse section are similar Based on this assumption, both the stress distribution and twist have been obtained as functions of time

Three sets of creep tests on Teak (*Tectona grandis*) (i) short term tests of 5 hours duration in tension parallel to grain, (ii) long term creep tests of 8 days duration in tension parallel to grain, (iii) creep tests in bending of 8 days duration, are described. Limit of plastic flow and equations of the form suggested in Reference 7 have been determined to fit experimental creep data in tension parallel to grain. From these experimental constants, using theory proposed in Reference 2 deflections have been predicted for creep tests in bending These predicted deflections have been compared with the experimental observations.

Creep tests in bending of two different species of timber have been described. The tests were carried out under two different conditions of temperature two different seasoning conditions and 4 different stress levels. Effect of these variables on both recoverable and irrecoverable creep has been studied.

All these investigations have been published in various papers listed in the Bibliography [2-8]

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KINETICS OF THE REACTION BETWEEN POTASSIUM PERSULPHATE AND MALIC ACID

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INTRODUCTION

The decomposition of potassium persulphate in aqueous solution and the effect thereon of various salts has been studied by a number of workers (I & II) In the reaction of potassium persulphate with hydrogen peroxide it has been observed that potassium persulphate probably reacts very slowly with hydrogen peroxide in aqueous solutions (III & IV) The oxidation of carbohydrate and related substances by means of potassium persulphate has also been studied (V) The reaction between potassium persulphate and oxalic acid both with and without a catalyst has been studied by many workers Kinetics of this reaction without a catalyst has been investigated from the viewpoint of the influence of different gases surfaces and electrolytes (VI)

From the above mentioned references it appears that kinetics of the reaction between potassium persulphate and malic acid has not been investigated. The investigations presented in this paper therefore were carried out in order to throw some light on the kinetics of the reaction between potassium persulphate and malic acid

EXPERIMENTAL

1 *Preparation of the solutions*—M/10 solutions of potassium persulphate, malic acid, and sodium thiosulphate were prepared in double distilled conductivity water

2 *Method of estimation*—For studying kinetics of reaction between potassium persulphate and malic acid a known volume of the acid of the desired strength was taken in a conical flask and kept in the thermostat maintained at 60°C When it had attained the temp of the bath a required volume of standard persulphate was added to the acid with the help of a pipette. The time of mixing the reactants was taken as the zero time. The initial amount of the persulphate and that after definite intervals of time was estimated by using a slightly modified method of Bartlett and Cotmann (VII) as used by Saxena and Singhal (VIII) The reaction was also studied at a temp of 70°C. From preliminary observations a temp. of 60°C was found to be suitable since at lower temps. the reaction is extremely slow

OBSERVATIONS

The reaction was studied with different initial concentrations of the reactants at 60°C and the velocity of reduction of potassium persulphate was

measured as described before. The reaction was also studied at 70°C in order to calculate temperature coefficient and the activation energy of the reaction. The results are summarised in the tables given in the last

(I) *Influence of Concentration of Malic Acid*

From table 1 it is observed that the decomposition of potassium persulphate increases gradually with the increase in molecular concentration of malic acid (fig 1)

(II) *Influence of Concentration of Potassium Persulphate*

From table 2 it is observed that the reduction of potassium persulphate increases with the increase in its molecular concentration (fig 2)

(III) *Influence of Temperature on the Reaction*

Comparing table 3 with conc. of malic acid = 0·02M in table 1 it is observed that the velocity of the reaction increases with rise of temperature by 10°C. The temperature co-efficient and energy of activation as calculated from the above observations are 1 595 and 10,860 calories respectively

DETERMINATION OF THE ORDER OF REACTION

The order of reaction between potassium persulphate and malic acid was determined by the following methods.

1 *Determination of order by equifractional parts method*—The titre value of $Na_2S_2O_3 \cdot 5H_2O$ (x) was plotted against time (t) in the cases when concentrations of malic acid were (M/50) and (M/100) and the concentration of potassium persulphate was (M/50) (Table 1)

Order of the reaction with respect to potassium persulphate is taken as one.

Formula used is $n = 1 + \dfrac{\text{Log } t - \text{Log } t_2}{\text{Log } C_2 - \text{Log } C_1}$

The order as calculated by using fig 3 is 1 3356 Hence the total order of the reaction may be taken as one, *i.e.*, the reaction is of the first order

2. *Van t Hoff's method*—The formula used is $n = 1 + \dfrac{\text{Log } K_2 - \text{Log } K_1}{\text{Log } C_2 - \text{Log } C_1}$

Here the order with respect to $K_2S_2O_8$ is one

(i) $C_1 = M/100$, $C_2 = M/50$ } Concentration of Malic Acid (table—1) $K_1 = 2{\cdot}589 \times 10^{-3}$ $K_2 = 3\ 197 \times 10^{-3}$ (min^{-1})

Concentration of potassium persulphate is fixed, *i.e.* (M/50) The value of n as calculated is 1 348 and hence the total order is one.

(ii) $C_1 = M/200$, $C_2 = M/100$ } Concentration of Malic Acid (table 1)

$K_1 = 2.330 \times 10^{-3}$ (min^{-1}) $K_2 = 2.569 \times 10^{-3}$($min^{-1}$)

The value of n as calculated is 1.151

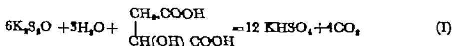
Here the total order is one.

3 The values of log $\frac{a}{(a-x)}$ plotted against t give a straight line. Hence the order of the reaction is one (fig 4)

Discussion

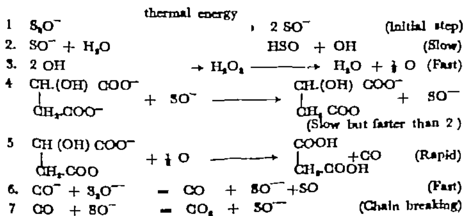
As investigated by a number of workers, the decomposition of potassium persulphate in aqueous solution is very slow and follows first order The decomposition of persulphate is accelerated in presence of malic acid. Thus it becomes clear that malic acid acts as a catalyst in the reaction. Similar effect has been observed by Saxena and Singhal in the decomposition of per sulphate in presence of oxalic acid and tartaric acid (VI & VIII) It is just possible that the nascent oxygen formed as a result of decomposition of potassium persulphate in aqueous solution oxidises malic acid to malonic acid with the liberation of free CO_2.

The reaction between potassium persulphate and malic acid can be expressed by the following stoichiometric equation



$$6K_2S_2O_8 + 5H_2O + \begin{matrix} CH_2.COOH \\ | \\ CH(OH)\ COOH \end{matrix} = 12\ KHSO_4 + 4CO_2 \qquad (I)$$

From equation (I) it is seen that the reaction should be of 10th order which, however is not possible. The reaction appears to be of first order as shown by observations in tables (1 to 3) It may therefore, be suggested that the reaction progresses in stages as shown by the following steps



1 $S_2O_8^{--} \xrightarrow{\text{thermal energy}} 2\ SO_4^{-}$ (Initial step)

2. $SO_4^{-} + H_2O \rightarrow HSO_4 + OH$ (Slow)

3. $2\ OH \rightarrow H_2O_2 \longrightarrow H_2O + \frac{1}{2}\ O$ (Fast)

4 $\begin{matrix} CH.(OH)\ COO^{-} \\ | \\ CH_2.COO^{-} \end{matrix} + SO_4^{-} \longrightarrow \begin{matrix} CH.(OH)\ COO^{-} \\ | \\ CH_2\ COO \end{matrix} + SO_4^{--}$ (Slow but faster than 2)

5 $\begin{matrix} CH\ (OH)\ COO^{-} \\ | \\ CH_2.COO \end{matrix} + \frac{1}{2}\ O \longrightarrow \begin{matrix} COOH \\ | \\ CH_2.COOH \end{matrix} + CO$ (Rapid)

6. $CO^{-} + S_2O_8^{--} = CO + SO_4^{--} + SO_4$ (Fast)

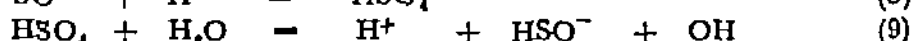
7 $CO + SO_4^{-} = CO_2 + SO_4^{--}$ (Chain breaking)

Step (1) probably being the slowest, determines the rate of the overall reaction The concentration of SO^- radical formed by the thermal decomposition of the S_2O^{--} ion may be taken to be proportional to the concentration of potassium persulphate. Hence in the presence of low concentration of acid the decomposition of potassium persulphate will be governed by step (1) to (3) in which step (1) is slowest Hence the reaction should follow first order as shown by tables 1 to 3 The fluctuations in the beginning of the values of the rate constant probably may be due to the catalysing influence of glass surface of the container of the reaction mixture.

With the increase in concentration of malic acid the H+ ions produced by it catalyse the step (2) with the result that velocity of production of nascent oxygen also increases



$$SO + H^+ \rightarrow HSO_4 \quad (8)$$



$$HSO_4 + H_2O \rightarrow H^+ + HSO^- + OH \quad (9)$$



$$SO^- + H_2O \rightarrow HSO + OH$$

The nascent oxygen so formed reacts with malic acid to produce malonic acid with the liberation of free CO^- which in turn reacts with S_2O^{--} as shown in step (6) to form CO_2,SO and free SO^- This free SO^- reacts with CO^- to form CO_2 and SO^{--} radical This last step is assumed to be the chain breaking process.

The authors are very grateful to Dr P I Ittyerah M Sc., Ph D (Agra) Ph D (Cantab) Head of the Chemistry Department, St. John's College, Agra for providing facilities for the present work.

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TABLE 1

Concentration of $K_2S_2O_8$ *= 0 02 M* *Temperature = 60°C*

t	Malic Acid = 0 005M		Malic Acid = 0 01 M		Malic Acid = 0·02 M.		Malic Acid = 0·05 M.	
	Titre volume of M/100 $Na_2S_2O_3$ (a−x)	K×10³ First Order (min⁻¹)	Titre volume of M/100 $Na_2S_2O_3$ (a−x)	K×10³ (min⁻¹)	Titre volume of M/100 $Na_2S_2O_3$ (a−x)	K×10³ (min⁻¹)	Titre volume of M/100 $Na_2S_2O_3$ (a−x)	K×10³ (min⁻¹)
0 mints.	40 ml.		40 ml.		40 ml.		40 ml.	
30	36 9	0 2694	35 3	0 4168	35	0 4452	35 3	0 6118
60	33 7	0 2859	32 8	0 3908	31 7	0 3876	28 9	0 5416
90	31 3	0 2727	30 5	0 3014	28 6	0 3728	25 7	0 4918
120	29 5	0 2599	28 3	0 2884	26 5	0 3433	22 7	0·4723
150	27 7	0 2450	26 1	0 2848	24 2	0 3351	20 6	0 4424
180	25 8	0 2437	25 1	0 2389	22 5	0 3197	18 2	0 4381
210	24 5	0 2335	23 1	0 2616	20 7	0 3157	16 3	0 4276
240	23 0	0 2306	21 5	0 2589 (Mean = 0 2767)	18 6	0 3191 (Mean = 0 3241)	14 4	0 4257
270	21 5	0 2300	20 2	0 2530	17 1	0 3148	12 5	0 4308 (Mean = 0 4309)
300	20 4	0 2243 (Mean = 0 2305)	18 7	0 2535	15 2	0 3226	10 8	0 4365
330	19 1	0 2330	16 9	0 2548	13 7	0 3247	9 4	0 4389
360	17 5	0 2297		...			7 6	0 4614
390	17 1	0 2179		...			6 7	0 4582
420	10 4	0 2171						

TABLE 2

Concentration of malic acid = 0·02 M — *Temperature = 60°C*

t	$K_2S_2O_8$ = 0·005 M: Titre volume of 0·005 M, $Na_2S_2O_3$ (a−x)	$K_2S_2O_8$ = 0·005 M: K×10⁴ (min⁻¹)		t	$K_2S_2O_8$ = 0·01 M: Titre volume of 0·01 M $Na_2S_2O_3$ (a−x)	$K_2S_2O_8$ = 0·01 M: K×10⁴ (min⁻¹)		$K_2S_2O_8$ = 0·05 M: Titre volume of 0·05 M, $Na_2S_2O_3$ (a−x)	$K_2S_2O_8$ = 0·05 M: K×10⁴ (min⁻¹)	
0 mints.	20·1 ml.			0 mints.	21·4 ml.			21·1 ml.		
30	16·1	0·7400		30	18·6	0·4675		19·8	0·1589	
60	13·7	0·6390		60	16·8	0·4034		18·9	0·1830	
90	12·2	0·5547		90	15·4	0·3656		17·8	0·1891	
105	10·9	0·5825		120	14·2	0·3418		16·9	0·1850	
120	10·3	0·5573		150	12·7	0·3479		16·0	0·1844	
135	9·4	0·5631		180	11·6	0·3402		15·4	0·1750	
150	8·8	0·5507		210	10·6	0·3346		14·8	0·1689	
165	7·7	0·5816		240	9·7	0·3393		14·3	0·1621	
180	7·2	0·5705		2 0	8·5	0·3420	Mean = 0·3576	13·6	0·1627	
195	6·5	0·5672	Mean = 0·5555	300	7·3	0·3565		13	0·1563	Mean = 0·1812
210	6·0	0·5757		330	6·5	0·3611		12·5	0·1567	
225	5·7	0·5601		360	5·6	0·3724		12·1	0·1545	
240	5·3	0·5555		390	4·7	0·3887		11·3	0·1536	
255	5·1	0·5379		420	4·0	0·3993		10·9	0·1575	
270	4·7	0·5383				...		...		
285	4·5	0·5252				...		...		
300	4·3	0·5141				...		...	...	

TABLE 3

$K_2S_2O_8$ = 0·02 M   Malic Acid = 0·02 M

Temperature = 70°C

t	Titre volume of 0·02M $Na_2S_2O_3$ (a–x)	K × 10² (min⁻¹)	
0 mints.	20 ml	...	
30	16·7	0·6010	
60	14·1	0·5626	
75	13·4	0·5339	
90	12·1	0·5383	
105	11·7	0·5106	
120	10·5	0·5309	
135	9·8	0·5267	
150	9·4	0·5034	
165	8·5	0·5186	
180	8·1	0·5022	Mean = 0·5171
195	7·2	0·5240	
210	7·0	0·5000	
225	6·5	0·4995	
240	5·8	0·5758	
255	5·5	0·4972	
270	5·2	0·4989	

PREPARATION OF N-α NAPHTHYL AND N-β NAPHTHYL MALONAMIC ACIDS AND SOME OF THEIR DERIVATIVES

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Reaction between aromatic amines and ethyl malonate has been studied by various workers Freund[2] prepared malonanilide by heating a mixture of aniline and ethyl malonate. A year later Rugheimer and Hofmann[10] studied the reaction between ethyl malonate and the three toluidines. Whiteley[11] prepared malonanilide from ethyl malonate and aniline malon-di-*p*-toluidide and malon-ethyl-*p* tolylamate from malonic ester and *p*-toluidine and malon-di-*o*-toluidide and malon-ethyl-*o*-tolylamate from malonic ester and *o*-toluidine. Seven years later Chattaway and Olmsted[2] described a good method for preparing malon-anilic acid and the three malon toluidic acids This work has been further extended by Ahluwalia, Haq and Ray These workers have prepared some derivatives of the above mentioned acids by condensing them with aromatic aldehydes. Work along the same lines have been carried out in this laboratory by Mehra and Pandya[7] Miss Pandya and Pandya[8] and Ittyerah and Pandya.[5] They have condensed over two dozens aromatic aldehydes with these acids with a view to study the reactivity of the methylene groups in these compounds and also to study the catalytic activity of organic bases like pyridine, piperidine, lutidine, quinoline, iso-quinoline and triethanolamine on these reactions.

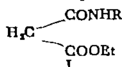
Ittyerah and Chellappa[6] prepared malon-1.3 4-Xylidic acid from malonic ester and 1.3 4-xylidine. They also reported the formation of malon-di-1.3 4-xylidide as well as malon-ethyl-1.3 4-xylidate. George and Ittyerah[4] prepared the malon-*o* *m* and *p*-chloranilic acids.

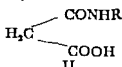
The condensation of malonic ester with aromatic diamines was first studied by Ramfrey The amine used was benzidine. T N Mehta and V B. Thosar have studied the action of malonic ester on benzidine, tolidine and *p*-phenylenediamine.

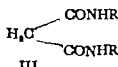
In this paper an attempt has been made to study the action of α naphthylamine and β-naphthylamine on malonic ester The only reference that could be obtained was a paper by Whiteley[12] in which she describes the preparation of malon-di-α-naphthylamide and malon-di β-naphthylamide and some of their derivatives

The present work was taken up with a two-fold object first to isolate and identify the products that could be obtained by the condensation of malonic ester with α and β-naphthylamines and second, to prepare some de

rivatives from the products thus obtained In reactions like this three main products can be expected. They are —







where R = α or β naphthylamino group

In the case of β-naphthylamine and malonic ester all the three products were isolated In the case of α naphthylamine and malonic ester only malon-di-α-naphthylamide (type III) and N-α-naphthyl-malonamic acid (type II) could be isolated easily Ethyl N-α naphthyl malonamate proved to be very unstable and could not be isolated

Another observation made in this connection was the effect of increasing the amount of malonic ester in these reactions. As can be seen from table 1 the yield of N β-naphthylmalonamic acid seemed to depend on the amount of malonic ester used The best yield (48 6%) was obtained when the molecular proportion of the amine to the ester was one to two. The same was found true in the case of α naphthylamine also

Next was an attempt to prepare the amides of the two acids thus obtained from α and β-naphthylamines The usual method of preparing an amide by converting the acid first to its acid chloride and then to the amide by treating with strong ammonia was tried This method was not successful On treatment with thionyl chloride the acids decomposed. So another method recommended by Whiteley[14] for the preparation of amides from similar acids was tried. Ethyl ester of N β-naphthylmalonamic acid was prepared and strong ammonia was added to it and the mixture kept for two days in a corked tube. On extraction this gave the amide. This could not be tried in the case of the α isomer as the corresponding ester could not be prepared.

Attempts to prepare additive compounds of these acids with *s* benzyl-thiuronium chloride were not successful.

Next attempt was to prepare some derivatives by condensing these acids with aromatic aldehydes The aldehydes selected were benzaldehyde and salicylaldehyde These condensations were carried out both in the presence and in the absence of condensing agents. Both pyridine and piperidine in traces were found to be good catalysts in these reactions This is in agreement with earlier observations published from this laboratory regarding the use of these bases as catalysts in the condensation of aromatic aldehydes with malonic acid[1] malonanilic acid malon-*o* *m* and *p* toluidic acids and malon 1.3 4-xylidic acid [4]

From N-α naphthylmalonamic acid and benzaldehyde, benzylidene-N-α naphthylmalonamic acid and N-α-naphthyl cinnamamide were obtained. From

N-β naphthylmalonamic acid and benzaldehyde, benzylidene N-β-naphthyl malonamic acid and N β-naphthyl-cinnamamide were obtained. The condensation of N-α-naphthyl and N-β-naphthyl-malonamic acids with salicylaldehyde did not take the usual course. The hydroxyl group in the aldehyde seemed to retard the reaction. There was a lot of resin formation and the yields of products obtained were poor when compared with those obtained from benzaldehyde. Different products were obtained according to the conditions employed and as further confirmation is required, the observations are not included in this paper but will be published later.

Experimental

Malon-Di β-Naphthylamide and N-β-Naphthyl Malonamic Acid

(7 *g*) β-naphthylamine and (8 *g*) freshly distilled ethyl malonate were refluxed together for 30-35 minutes in a R. B. flask with an air condenser of such a length as to allow the alcohol formed during the reaction to escape but not the ester. During heating a white crystalline substance started separating out. After heating the contents of the flask were cooled and (50 *ml*) rectified spirit added. The white crystalline compound that separated was filtered, washed and purified (*m. p* 235°). On cooling this re-solidified and did not melt even upto 300°. This compound was found to be identical with Malon-di-β-naphthylamide whose m. p was reported by Whiteley[13] as 235 300°.

To the filtrate, 10 *g* of sodium carbonate dissolved in 75 *ml* distilled water was added and steam blown through it for about 25 minutes. A further portion of malon-di-β-naphthylamide that separated was filtered off and the filtrate acidified with conc HCl. A pinkish sticky solid substance separated which on standing turned brittle. This compound could be purified by recrystallisation from alcohol. The shining pinkish white crystals were identified to be those of N β-naphthyl-malonamic acid m. p 176° (*d*) (Found N 6 2 Eq wt 229.2; $C_{13}H$ NO_3 req N 6.12% Eq wt. 229)

Table 1

Effect on yield of the products by increasing the quantity of ethyl malonate

Mol. proportions of β-naphthylamine and ethyl malonate	Yield per cent Malon-di-β-naphthylamide.	Yield per cent N-β-naphthyl-malonamic acid.
1 1	20 55	17 84
1 : 1 5	28 90	37 46
1 2	31 42	48 60

Ethyl N β-Naphthyl malon-amate

After filtering off the malon-di β-naphthylamide obtained by condensing together β-naphthylamine and ethyl malonate as described earlier the alcoholic extract was evaporated to dryness in a porcelain basin on a water bath. White shining crystals were left behind which after purification by repeated recrystallisations from dilute alcohol was identified to be Ethyl N β-Naphthyl-malonamate. It melted at 121

The identity of the compound was further confirmed by alkaline hydrolysis of the same followed by iodoform reaction which was found to be positive even in cold suggesting the presence of ethyl alcohol after hydrolysis. On heating there was a smell of phenyl isocyanide probably indicating that the potassium salt of the acid got decomposed into the parent amine which responded to the carbylamine reaction. (Found N 5.58 $C_{15}H_{15}NO_3$ req N 5 45 %)

N β Naphthyl-malonamic acid amide

The thionyl chloride method for preparing the acid amide was unsuccessful. 0·5 *g* of ethyl N β-naphthyl-malonamate were mixed with 5 ml liq ammonia in a corked test tube and the mixture left for two days The t. t was shaken occasionally The white precipitate obtained was filtered washed repeatedly with water and recrystallised from hot benzene. This compound melted at 200 and responded to the usual tests for amides and was identified to be the N β-naphthyl-malonamic acid amide. (Found N 12 09 $C_{13}H_{12}N_2O_2$ req N 12.3%)

Benzylidene N β-naphthylmalonamic acid and N-β-naphthyl-cinnamamide

N-β-naphthyl-malonamic acid (1 2 *g*) and benzaldehyde (2 5 *g*) were heated in a R. B. flask for five hours on a boiling water bath After melting to a pale yellow coloured liquid, the mass re-solidified after some time. The product was extracted by a saturated solution of sodium bicarbonate. The alkali extract was acidified with conc HCl and the precipitate obtained was recrystallised from hot alcohol. This product melted at 167 (d) and was identified to be benzylidene N β-naphthylmalonamic acid (Found N 4 70 Eq wt. 317 6 $C_{20}H_{15}NO_3$ req N 4 42%, Eq wt., 317)

When condensation was carried out under the same conditions but with a trace of piperidine as condensing agent, the reaction was found to be more vigorous There was a copious evolution of CO_2 and H_2O and the deep orange yellow coloured liquid set to a solid mass after two hours. When this product was treated with a saturated sodium bicarbonate solution hardly any reaction took place The residue was then filtered washed, purified by recrystallisation from hot alcohol and was found to melt at 166 This compound was identified to be N β-naphthyl cinnamamide. (Found N 5 102 $C_{19}H_{15}NO$ req. N 5 13%)

TABLE 2

Showing the products obtained on condensation of N-β-naphthyl-malonamic acid with benzaldehyde

Conditions of experiment				Yield per cent	
Condensing agent	Mol. proportion	Temp.	Time	Benzylidene N-β-naphthyl malonamic acid	N β-naphthyl-cinnamamide
Nil	1 : 1	100°	5 Hrs.	90 25	nil
Piperidine	1 : 1			nil	90 84

Malon-di-α-naphthylamide and N-α-naphthyl-malon-amic acid

By refluxing together for 30 minutes α naphthylamine and ethyl malonate in a R B flask with an air condenser of such a length that allowed the alcohol to escape but not the ester and then adding some rectified spirit and cooling under tap dirty white flakes of a substance separated as an insoluble substance. This product was highly insoluble and could be recrystallised only from hot glacial acetic acid or pyridine. It melted at 225 with slight decomposition and was found to be identical with malon-di-β-naphthylamide as reported by Whiteley[11] who also reports the same m. p

The filtrate was treated with a solution of 10 *g* sodium carbonate in 75 ml distilled water and then steam was blown through it for 25 minutes After filtration of the additional quantity of malon-di-β naphthylamide and acidification of the filtrate by conc. HCl, a pinkish white precipitate was obtained. This was recrystallised from acetone and was found to melt at 158° (d) It was identified to be N-α-naphthyl-malonamic acid. (Found : N 6.34 Eq wt., 228.3 $C_{13}H_{11}NO$ req N, 6.12% Eq wt. 229)

The acid was found to be quite unstable in comparison to its β-isomer as when the neutral salt solution of the acid was being prepared by adding excess of ammonia and then boiling off the excess resulted in the formation of a violet coloured compound which was identified to be α naphthylamine.

TABLE 3

Showing the effect of quantity of ethyl malonate on the yield of products

Mol. proportions of α-naphthylamide and ethyl malonate	Yield per cent	
	Malon-di-alpha naphthylamide.	N-α-naphthyl-malonamic acid.
1 : 1	26 04	22 30
1 : 2	29 17	35 50

Benzylidene N-α-naphthyl-malonamic acid and N α-naphthyl-cinnamamide

Benzaldehyde and N-α-naphthylmalonamic acid were heated together in 1 1 molecular proportions in a R. B. flask on a boiling water bath for five hours. After 30-45 minutes of heating the contents melted to a muddy yellow liquid and finally resolidified. By following the usual method of extraction by saturated solution of sodium bicarbonate and subsequent precipitation by adding conc HCl, a white compound was obtained This on purification was found to be benzylidene N-α-naphthyl malon amic acid m.p 200°(d) (Found N 4 146 Eq wt. 316 5 $C_{20}H_{15}NO_3$ req N 4 42% Eq wt. 317)

In presence of a trace of piperidine as condensing agent the main pro uct isolated was a non acid one This compound on purification from hot rectified spirit yielded a pale yellow crystalline mass m.p 215 and was identified as N-α naphthyl-cinnamamide. (Found N 5 03 $C_{19}H_{15}NO$ req N 5 13%)

TABLE 4

Showing products obtained on condensing benzaldehyde with N-α-naphthyl-malonamic acid.

Conditions of experiment				Yield per cent	
Condensing agent	Mol. proportion	Temp.	Time	Benzyliden N-α naphthyl malo amic acid	N-α-naphthyl cinnamamid
nil	1 1	100°	5 hrs.	60 05	nil
Piperidine	1 : 1 : 0 15			nil	90 81

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STEADY HYDROMAGNETIC FLOW IN A CHANNEL WITH POROUS WALLS IN THE PRESENCE OF A TRANSVERSE MAGNETIC FIELD

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In the present paper is studied the problem of steady flow of an electrically conducting incompressible, viscous fluid of constant electric and magnetic properties in the space between two parallel porous infinite plane walls in the presence of a transverse magnetic field. The general magnetohydrodynamic equations are simplified by the conditions of the problem to mainly three equations. Two of these equations are coupled for the velocity and the magnetic field and are capable of an exact solution. The third gives the variation of pressure. When the suction or injection at the walls is made to vanish the flow reduces to the Hartmann flow.

Introduction

This paper deals with the flow of an incompressible, viscous, electrically conducting fluid in a channel bounded by infinite, parallel, non-conducting porous plane walls with uniform suction and injection in the presence of a transverse magnetic field. The theory of flow of conducting viscous fluids between parallel (non-conducting and non-porous) walls in the presence of a uniform transverse magnetic field known as Hartmann flow problem is now a textbook work (e.g. Cowling) [1]. Effects of porous boundaries on the hydrodynamic flow in systems with various geometries have been considered by Berman.[2] He has taken mainly three types of boundaries in that paper as a pipe with cylindrical cross section, a channel with rectangular cross section and an annulus formed by two concentric pipes (restricting to laminar incompressible flow). There he has cited a number of references to the works of other authors along with his own, and it has been found that fluid injection or withdrawal through the boundaries has interesting effects on the velocity profiles and pressure gradients. However the effects of porous boundaries on hydromagnetic flow to the author's knowledge, do not appear to be given anywhere except a paper by Kakutani[3] which considers the magnetohydro

1 T. G. Cowling, Magnetohydrodynamics (Interscience Publishers, Inc., New York, 1957) p. 13.

2 A. S. Berman Proceedings of the second International Geneva Conference (Geneva) Vol. 4 pp. 351-358 (1958)

3 T. Kakutani, ZAMP Vol. XII pp. 219-230 (1961)

dynamic flow over a plane wall with uniform suction, commenting on a paper by Gupta[4] (whose solution is not satisfactory)

The object of the present paper therefore is to provide an exact solution of the problem considered Detailed discussions and numerical results have not been reproduced here to avoid the increase in the length of the paper

The Governing Equations

The equations governing the flow of an electrically conducting fluid in the presence of a magnetic field are simultaneous equations of modified Navier Stokes and Maxwell's equations taking account of the interaction between the field and motion. As we are not considering problem involving conductors with rapid oscillations, Maxwell's displacement currents and accumulation of charges are neglected Assuming that the only body force in the field is the Lorentz-force the equations of hydromagnetic flow are[5]

$$\text{curl } \mathbf{H} = 4\pi \mathbf{J} \tag{1}$$

$$\text{curl } \mathbf{E} = -\mu \frac{\partial \mathbf{H}}{\partial t} \tag{2}$$

$$\text{div } \mathbf{H} = 0 \tag{3}$$

$$\mathbf{J} = \sigma(\mathbf{E} + \mu \mathbf{V} \times \mathbf{H}) \tag{4}$$

$$\text{div } \mathbf{V} = 0 \tag{5}$$

and

$$\frac{\partial \mathbf{V}}{\partial t} + (\mathbf{V} \text{ grad}) = \mathbf{V} - \frac{1}{\rho} \text{ grad } p + \nu \nabla^2 \mathbf{V} + \frac{\mu}{\rho} \mathbf{J} \times \mathbf{H} \tag{6}$$

where $\mathbf{H}$ is the magnetic field $\mathbf{E}$ the electric field $\mathbf{V}$ the velocity $\mathbf{J}$ the current density μ the permeability ρ the density ν the kinematic coefficient of viscosity and p the pressure and *c.g.s* electromagnetic units have been employed.

$\mathbf{E}$ and $\mathbf{J}$ can be eliminated from (1) (2) and (4) to give

$$\frac{\partial \mathbf{H}}{\partial t} = \text{curl } (\mathbf{V} \times \mathbf{H}) + \lambda \nabla^2 \mathbf{H} \quad \ldots \quad \ldots \tag{7}$$

where $\lambda = 1/(4\pi\mu\sigma)$ and is the magnetic diffusivity of the fluid.

Elimination of $\mathbf{J}$ in (1) and (6) making use of (3) and (5) gives

$$\frac{\partial \mathbf{V}}{\partial t} + (\mathbf{V} \text{ grad})\mathbf{V} = -\text{grad}\left(\frac{p}{\rho} + \frac{\mu}{8\pi\rho} |\mathbf{H}|\right) + \frac{\mu}{4\pi\rho}(\mathbf{H} \text{ grad})\mathbf{H} + \nu \nabla^2 \mathbf{V} \ \ldots \tag{8}$$

We choose a right handed system of axes of cartesian coordinates in such a way that the walls are normal to the z axis and situated at $z = \pm L$. Walls have been assumed to be electrically non-conducting and to have the same permeability as that of the fluid The fluid flows past along Ox and

4 A. S Gupta, ZAMP Vol. XI pp. 43-49 (1960)

5 See reference 1 p 3

a transverse uniform magnetic field H_0 is applied to it. The equations governing the flow are simplified on account of the following assumptions

(I) All physical quantities are independent of the space function y

Therefore $\frac{\partial}{\partial y}=0$

(II) Flow is steady and laminar hence $\left(\frac{\partial}{\partial t}\right)=0$

(III) The fluid injection rate at one wall is taken equal to the fluid withdrawal rate at the other wall. This condition is satisfied by

$$v_z(L)=v \quad (-L)=v \quad (z)=v=\text{Constant} \tag{9}$$

where v_z (L) v (−L) $v_z(z)$ are the cross-flow velocities (parallel to O_z) at the walls =L, z=−L and at any point $(x\ y\ z)$ in the channel espectively

(IV) The longitudinal component of velocity is taken in the direction of x axis, so that $v_y=0$ and equation of continuity (5) then reduces to

$$\frac{\partial v}{\partial}=0 \quad \ldots \tag{10}$$

where v denotes the longitudinal component of veloc ty

(V) The externally applied un form magnetic field H parallel to O_z fixes the normal component of the magnetic field at the surfaces of the planes =L and $z=-$L and that this is the only field impressed. There is no applied electric field and also there are no free charges and hence $\mathbf{E}=0$

Since the liquid near the meridian plane is moving faster than that near the walls it tends to pull out the lines of force in the direction of motion Thus the field acquires a component H parallel to O_x

Equation (3) reduces to

$$\frac{\partial H}{\partial x}=0 \tag{11}$$

We have

$$\mathbf{V}=(\quad 0\ v\ )$$
$$\mathbf{H}=(H\quad 0, H\ )$$

and hence

$$\mathbf{V}\times\mathbf{H}=(0\ \ v\,H\ -v\ H_0,\ 0) \tag{12}$$

where the quantities in the parentheses denote respectively the $x\ y\ z$ components of the corresponding vectors

Since there is no applied electric field and free charges, equation (4) gives,

$$J\ =0 \tag{13}$$
$$J_y=\kappa\sigma(v_0H\ -v\ H_0) \tag{14}$$
$$J\ =0 \quad \ldots \tag{15}$$

It is obvious now that in this problem curl H, V×H and J have only y component Equation (1) gives

$$(\text{curl } H)_y = \frac{\partial H_x}{\partial z} = 4\pi J_y \quad (16)$$

Equations (14) and (16) give

$$\frac{\partial H_x}{\partial z} = 4\pi J_y = \frac{1}{\lambda}(v_0 H_x - v_x H_0) \quad (17)$$

With the above results equations (7) and (8) reduce to the following three equations

$$H \frac{dv}{dz} - v_0 \frac{dH}{dz} + \lambda \frac{d^2 H}{dz^2} = 0 \quad (18)$$

$$\frac{\partial p}{\partial z} + \frac{\mu}{8\pi} \frac{dH_x^2}{dz} = 0 \quad (19)$$

and

$$v_0 \frac{dv_x}{dz} = -\frac{1}{\rho} \frac{\partial p}{\partial x} + \nu \frac{d^2 v}{dz^2} + \frac{\mu H}{4\pi\rho} \frac{dH}{dz} \quad (20)$$

Here v and H are functions of z only on account of (10) (11) and assumption (I) Differentiating (19) with respect to x

$$\frac{\partial^2 p}{\partial x \partial z} = 0 = \frac{\partial}{\partial} \left(\frac{\partial p}{\partial x}\right) \text{ showing that } \frac{\partial p}{\partial x} \text{ is independent of } z.$$

Differentiating (20) with respect to x we find $\frac{\partial}{\partial x}\left(\frac{\partial p}{\partial x}\right) = 0$ which shows that $\frac{\partial p}{\partial x}$ is independent of x also

We therefore take

$$-\frac{\partial p}{\partial x} = P = \text{constant} \quad (21)$$

Equations (19) and (21) give

$$p + Px + \frac{\mu}{8\pi} H^2 = \text{constant} \quad (22)$$

After determining H pressure p can be determined

The boundary conditions for velocity and magnetic field are

$$v(L) = 0 \quad v(-L) = 0 \quad H(L) = 0 \quad H(-L) = 0 \quad (23)$$

The first two of (23) are no slip conditions on the walls of the channel. The third and fourth are the conditions of continuity of the tangential component of the magnetic field at the fluid-wall interfaces (for the walls have been assumed to be non-conducting) Since it has been assumed that the permeability of the walls is same as that of the fluid the condition of continuity of the normal component of the magnetic induction is compatible with our assumption that the magnetic field is of intensity H and parallel to the z axis outside

the fluid and H_0 is the z—component of magnetic field in the fluid—a fact which has already been employed in the reduction of the equations

NON DIMENSIONAL FORM OF THE EQUATIONS.

The essential equations of the flow are (18) and (20) in association with (21) We define the following non-dimensional quantities

$$v = v\sqrt{\frac{\rho}{PL}} \quad H = \frac{H}{H_0} \quad \zeta = \frac{z}{L} \quad \pi = \frac{p}{PL} \tag{24}$$

With these substitutions the equations (19) and (20) reduce to

$$\frac{dv}{d\zeta} - \frac{1}{R_c}\frac{dH}{d\zeta} + \frac{1}{R_m}\frac{d^2H}{d\zeta^2} = 0 \tag{25}$$

and

$$1 + S^2\frac{dH}{d\zeta} - \frac{1}{R_c}\frac{dv}{d\zeta} + \frac{1}{R}\frac{d^2v}{d\zeta^2} = 0 \tag{26}$$

where our non-dimensional flow characteristics are

R = Reynolds number for the longitudinal flow

$$= \sqrt{\frac{PL}{\rho}}\ \frac{L}{\nu} \tag{27}$$

$$R_m = \text{Magnetic Reynolds number} = \sqrt{\frac{PL}{\rho}}\ \frac{L}{\lambda} \tag{28}$$

$$S^2 = (\text{Magnetic pressure number})^2 = \frac{\mu H}{4\pi PL} \tag{29}$$

and R_c = Reynolds number for the cross-flow $= \sqrt{\dfrac{PL}{\rho}}\ \dfrac{1}{\nu}$ (30)

and the corresponding boundary conditions become

$$v(1) = 0 \quad v(-1) = 0 \quad H(1) = 0 \quad H(-1) = 0 \tag{31}$$

SOLUTION OF EQUATIONS

Equations (25) and (26) are ordinary linear differential equations and their first integrals are respectively

$$\frac{1}{R_m}\frac{dv}{d\zeta} - \frac{1}{R_c}H + v = C_1 \tag{32}$$

and

$$\frac{1}{R}\frac{dv}{R\zeta} - \frac{1}{R_c}v + S^2H + \ = C_2 \tag{33}$$

Elimination of H between (32) and (33) leads to second order differential equation in v which can be exactly solved.

The resulting equation is

$$\frac{d^2v}{d\zeta^2} - \frac{R_m + R}{R_c}\frac{dv}{d\zeta} + \left(\frac{RR_m}{R^2} - RR_mS^2\right)$$

$$= -\frac{RR_m}{R_c}\zeta - R - RR_mS^2C_1 - \frac{RR_m}{R_c}C_2 \tag{34}$$

Solving this equation by usual procedure and taking account of the boundary conditions (31) on the velocity and magnetic field, the solution is as follows

Let α, β be the roots of the quadratic equation

$$\zeta^2-\left(\frac{R_m+R}{R_e}\right)\zeta+\left(\frac{RR_m}{R_e^2}-RR_mS^2\right)=0 \qquad \text{..} \qquad (35)$$

$$v=-\frac{RR_m}{\alpha(\alpha-\beta)}\frac{\left(\frac{\alpha}{R_m}-\frac{1}{R_e}\right)}{\mathrm{Sin\,h}\,\alpha}\left(e^{\alpha\zeta}-e^{\alpha}\right)+\frac{RR_m}{\beta(\alpha-\beta)}\frac{\left(\frac{\beta}{R_m}-\frac{1}{R_e}\right)}{\mathrm{Sin\,h}\,\beta}\left(e^{\beta\zeta}-e^{\beta}\right)$$

and

$$+\frac{RR_m}{R_e}\frac{(\zeta-1)}{\alpha\beta} \qquad (36)$$

$$H=\frac{RR_m}{S^2}\frac{\left(\frac{\alpha}{R_m}-\frac{1}{R}\right)\left(\frac{\alpha}{R}-\frac{1}{R_e}\right)}{\alpha(\alpha-\beta)\,\mathrm{Sin\,h}\,\alpha}\left(e^{\alpha\zeta}-e^{\alpha}\right)$$

$$-\frac{RR_m}{S^2}\frac{\left(\frac{\beta}{R_m}-\frac{1}{R_e}\right)\left(\frac{\beta}{R}-\frac{1}{R}\right)}{\beta(\alpha-\beta)\,\mathrm{Sin\,h}\,\beta}\left(e^{\beta\zeta}-e^{\beta}\right)+\frac{(\zeta-1)}{S^2}\left(\frac{RR_m}{R}-1\right) \qquad (37)$$

The value of the current density can be found from equation (17) after substituting H and v obtained from (36) and (37)

Similarly the pressure variation can be obtained from equation (22) after substituting for H from (37)

This completes the solution of the hydromagnetic equations. The results apply equally well for either direction of the cross flow in the channel (due to fluid injection at one plate and removal through the other) Positive value of v_0 represents suction at the plane wall $z=L$ and injection at the plane wall $z=-L$, while negative value of v represents suction at the plane wall $z=-L$ and injection at the plane wall $z=L$.

LIMITING FORMS OF THE FLOW

(I) In the absence of the cross flow $v_0=0$ and hence $\frac{1}{R}=0$ and from equation (35) it can be seen that in this case

$$\alpha=-\beta=\sqrt{RR_mS^2}=\mu H_0L\sqrt{\frac{\sigma}{\rho\gamma}}=M$$

where M is the Hartmann number From equations (36) and (37) with substitutions from (21) we get

$$(\;)_{\to 0}=\frac{PM}{\mu^2\sigma H}\left[\frac{\mathrm{Cos\,h}\,M-\mathrm{Cos\,h}\left(\frac{M}{L}\right)}{\mathrm{Sin\,h}\,M}\right]$$

and

$$(H_x)_{\to 0}=\frac{4\pi PL}{\mu H}\left[\frac{\mathrm{Sin\,h}\left(\frac{M}{L}\right)}{\mathrm{Sin\,h}\,M}-\frac{}{L}\right]$$

This corresponds to Hartmann flow (if E, the applied electric field is set equal to zero) [6]

(II) When the electrical conductivity of the fluid σ and hence R_m is supposed to be zero there will exist no current in the field and hence the flow will not interact with the magnetic field

In this case $\alpha, \beta = O \dfrac{R}{R_e}$

The result agrees with that given by Berman[7] and the expression for velocity is same as his equation (25) or equations (38) and (41) of Narasimhan[8] after necessary changes in the symbols.

(III) When the magnetic field vanishes, $H_0 = O$ and $S = O$ In this case $\alpha, \beta = O \dfrac{R}{R_e}$ and the results again are the same as in the limiting case (II) above.

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IDENTIFICATION OF THE OXIDATION PRODUCTS OF ALIPHATIC ALDEHYDES KETONES AND OF ISO PROPYL ALCOHOL BY PERSULPHATE ION

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A knowledge of the products formed in a reaction subjected to kinetic study is an important step in the elucidation of the mechanism of a reaction. We have studied the kinetics of the oxidation of formaldehyde[1] acetaldehyde[2] propionaldehyde[3] different aliphatic ketones[4] and of iso-propyl alcohol[3] by persulphate ion in presence of Ag^{+} ion as catalyst Therefore it was considered necessary to identify the various products formed in these oxidation reactions

After isolation by suitable methods the carboxylic acids obtained were identified by spot tests. These tests are given by Feigel.[5]

The tests were carried out in the distillate obtained by distilling the reaction mixture (after keeping it for 24 hours) between 92°C and 95°C. The piperidine-sodium nitroprusside test for acetic acid was applied after neutralising the distillate with NH_4OH and evaporating to dryness.

The lower members of the fatty acid series may rapidly be distinguished by testing firstly with acid permanganate which is decolourised by formic acid but by none of its homologues, the latter differ in the solubility of their ferric and cupric salts in organic acids. For propionic and butyric acids, the reaction mixture after keeping for 24 hours was treated with potassium chloride solution to precipitate out the Ag^{+} ion The filtrate was boiled with NH OH and was concentrated. NH OH was added from time to time and boiled till whole of the persulphate was decomposed (tested with KI and starch) The solution after concentration was boiled thoroughly to remove the last traces of ammonia and then the ferric chloride test was performed as follows —

To 2 c.c. of the resulting solution 1 c. c. of iso-amyl alcohol (preferably diluted with half its volume f methyl alcohol) and 1 or 2 drops of 2% queous ferric chloride solution are added. The mixture is well shaken and allowed to stand until it separates into two layers. In the case of acetic acid (and formic acid also) the aqueous layer is coloured and the iso-amyl alcohol layer is colourless with propionic acid and higher homologues the colour is entirely in the alcohol layer With butyric and higher acids the test is repeated substituting ethyl ether for iso-amyl alcohol, when the colour is taken up by the ether layer

This investigation showed the presence of the following oxidation products in the different reactions

TABLE

Sl No	Compound oxidised	Products detected
1	Acetone	acetic and formic acids.
2	CH_3-ethyl ketone	formic, acetic and propionic acids
3	Di-ethyl ketone	acetic and propionic acids.
4	CH_3-n pro ketone	formic, acetic, propionic and butyric acids.
5	CH_3—iso pro ketone	formic, acetic, propionic and butyric acids.
6.	Formaldehyde	formic acid.
7	Acetaldehyde	acetic acid
8	Prop onaldehyde	propionic acid.

Product formed in the oxidation of iso-propyl alcohol by $K_2S_2O_8$ —In the oxidation of iso-propyl alcohol by $K_2S_2O_8$ the first product formed is acetone as suggested by Levitt and coworkers[6] We have confirmed the presence of acetone in the reaction mixture by preparing the 2 4 dinitrophenyl hydrozone.

ACKNOWLEDGEMENT

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THE CRANIAL NERVES OF *MYSTUS SEENGHALA* (SYKES)

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INTRODUCTION

Besides the general account in text books, very little work is available on the cranial nerves of fishes. The only important references are from Wright (1884) Ewart (1889) Cole (1898) Allis (1897 1920) Herrick (1899-1901) Workman (1900) Berkelbach (1915),Brookover and Jackson (1911) Norris and Hughes (1920) Atoda (1936) Young (1939) Ray (1950) and Sinha (1956)

Feeling the need of the study on the subject, I was advised by Dr B M. Sinha to take up investigations on the common Indian types. The present attempt provides a reasonably complete account of the cranial nerves of the siluroid fish, *Mystus seenghala* (Sykes) and studies on other teleostean fishes will be taken up in due course.

The work has been carried under the supervision of Dr B M. Sinha and I am thankful to him for his guidance. My acknowledements are also due to the authorities of Meerut College for providing the necessary facilities for work.

MATERIAL AND METHODS

The fish were mostly obtained from the local fish market, from Delhi and adjoining districts. The head part of the fish was severed from the body and a superficial dissection of its nerves was attempted. It was then kept in 8% solution of formalin and the tracing of nerves with regard to their origin and distribution was attempted on the preserved specimens.

The dissections were done along the dorsal ventral and lateral aspects of the fish. To ascertain the full distribution of the trigeminal and facial nerves dissections along the ventral aspect of head was also undertaken For the origin of various nerves the brain was carefully removed with the roots of nerves intact and was studied under the binocular microscope.

OBSERVATIONS

The *nervus olfactorius* (I 1 olf n) arises from the anterior end of olfactory lobe. The nerve is small as the olfactory lobe is situated close to the olfactory sac. It immediately divides into two branches, which supply the double row of olfactory folds.

The *nervus opticus* (II 2 & III opt.) originates from the ventral side of optic thalamus. Within the cranium it crosses to the other side forming the optic chiasma. It runs enclosed in tough endorhachis and comes out in the

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orbit through the optic foramen, situated in between the parasphenoid and pleurosphenoid. The nerve supplies the retina of eye ball.

The *nervus oculomotorius* (II 1 III & IV 2 ocul.) takes its origin from the ventral part of mid brain concealed below the inferior lobe It comes out in the orbit through the foramen of the trigemino-facial complex, which is bounded by the prootic, pleurosphenoid and parasphenoid. In the middle of its course it divides into a superior and an inferior branch. The *superior branch* innervates the superior rectus muscle. The *inferior branch* enters between the superior and inferior recti muscles and gives a branchlet, which running ventral to the inferior and anterior recti muscles terminates in the inferior oblique muscle. The main inferior branch now divides into two branchlets, a dorsal and a ventral. The dorsal branchlet supplies the inferior rectus muscle and the ventral branchlet innervates the anterior rectus muscle.

The *nervus trochlearis* (II-2, III & IV 2 troch.) originates from the dorso-lateral surface of the mid brain lying between the optic lobes and cerebellum posterior to the origin of nervus oculomotorius. In the cranium its course is concealed below the trigemino-facial complex. The nerve comes out in the orbit through the foramen for the trigemino-facial complex and continues in front lying dorsal to the other eye muscle nerves. It innervates the superior oblique muscle of eye.

The *nervus abducens* (II 2 III & IV 2 abd.) arises below the anterior end of medulla oblongata, posterior to the origin of trigeminal nerves and runs below the acustic tubercle. It comes out in the orbit through the foramen of trigemino-facial complex. Extracranially the nerve passes below the nervus oculomotorius and innervates the posterior rectus muscle of eye.

The nervus trigeminalis and nervus facialis originate from the side of medulla oblongata separately but immediately unite to form the *trigemino-facial* complex (IV 2 tfc.) Within the cranium the complex separates into three trunks, the supraorbital infraorb tal and hyomandibular

The *supraorbital trunk* (I II 1 III & IV 2 s.o.t.) is the dorsal most trunk of the trigeminofacial complex which runs for a short distance in the cranium and at the level of the anterior end of cerebellum divides into two branches, the ophthalmicus superficialis trigemini and ophthalmicus superficialis facialis. Both the branches come out into the orbit through the foramen of the trigemino-facial complex. The *ophthalmicus profundus* is absent.

The *ophthalmicus superficialis trigemini* (II 1 oph tr) runs in the orbit in between the protractor hyomandibularis and adductor arcus palatini muscles, attached to the trochlear nerve. After a short course it gives a thin branch, which crossing over the superior oblique muscle of eye supplies the skin of head. The main nerve pierces the lateral ethmoid and separates into thin branchlets which supply the overlying skin of snout.

The *ophthalmicus superficialis facialis* (II 1; oph. fc.) is the dorsal branch of the supraorbital trunk. In the orbit it lies along the ventral surface of frontal and by the side of parasphenoid. Like the ophthalmicus superficialis trigemini it pierces the lateral ethmoid and terminates into small branchlets, which innervate the skin and sense organs of snout. Some of the terminal branchlets overlap the branchlets of the ophthalmicus superficialis trigemini in their course. All along the course, small fibres escape from the ophthalmicus superficialis facialis, which innervate the supraorbital canal of lateral line system.

The *infraorbital trunk* (I II 1 III & IV 2 i.o t.) divides intracranially into the ramus maxillaris ramus buccalis and ramus mandibularis. The three rami come out of the cranium through the foramen for the trigemino-facial complex and run together for a short distance before diverging in their directions.

The *ramus maxillaris trigemini* (II 1 III & IV-2 r mx. tr) runs dorsal to the muscle adductor arcus palatini and on the inner side of muscle adductor mandibularis fourth in the direction of maxillary barbel In its early run, it gives the *ramus palatinus anterior* (I & III r pl. a.) from its inner side, which dividing into fine twigs terminally supplies the roof of mouth. Under the eye the ramus maxillaris trigemini divides into two branches, which run parallel to each other The inner branch supplies the upper lip and premaxillary teeth by two branchlets, while the outer branch innervates the maxillary barbel.

The *ramus buccalis* (I III & IV r buc.) arises from the upper most part of infraorbital trunk and passes forward in close contact with the ramus maxillaris trigemini along the inner border of the muscle adductor mandibularis fourth. In its early course it gives a branch laterally to the skin of eye and under the eye anastomoses with ramus maxillaris through a branch. Towards its end the nerve comes to lie on the outer border of olfactory capsule, where it divides into two branchlets, a dorsal and a ventral. The dorsal branchlet supplies the skin of nasal sac and the muscle adductor arcus palatini, while the ventral branchlet innervates the sense organs on maxillary barbel. The nerve supplies the infraorbital canal of lateral-line system in its course.

The *ramus mandibularis trigemini* (II 1 III & IV 2 r md. tr) is the most prominent branch of the trigemino-facial complex. After emerging into the orbit, it runs along the ramus maxillaris for a short distance and then diverges along the inner border of muscle adductor mandibularis fourth At the level of the posterior border of eye it separates into two unequal branches, a thin ramus mandibularis externus and a stout ramus mandibularis internus. The *ramus mandibularis externus* (II 1 md. ex.) runs superficially on the outer surface of lower jaw and divides into two branchlets, which supply the skin of lower jaw After giving a thin branch to muscle intramandibularis the *ramus mandibularis internus* (IV 1 r md. in.) runs in a deeper course in the

mandible. The nerve gives a thin branch to the overlying skin under the dentary and then separates near the insertion of muscle pars-lateralis into four branchlets one behind the other The first branchlet supplies the muscle intermandibularis anterior while the fourth branchlet innervates the pars superficialis, pars-lateralis and pars-medialis of the muscle intermandibularis posterior The second and the third branchlets supply the mandibular and mental barbels respectively

Just after its emergence from the cranium the main ramus mandibularis trigemini gives three nerves in the direction of the muscles adductor mandibulae. The first nerve, which escapes by the side of ramus mandibularis trigemini crosses the muscle adductor mandibularis fourth and supplies the muscle adductor mandibularis third by thin branchlets. The remaining two nerves come out dorsally and innervate the muscle adductor mandibularis second and muscle adductor mandibularis fourth

The *hyomandibular trunk* (II 1 III & IV 2 hmt.) comes out in the orbit through a foramen in the prootic bone. Soon after emergence it gives the *ramus palatinus posterior* (I & III r pl.p) which goes to the anterior end of head passing beneath the nerves of infraorbital trunk. It runs dorsal to muscle adductor arcus platini and along the ramus palatinus anterior About the anterior end of head it passes over the muscle extensor tentaculi and giving a branchlet to it, supplies the palate.

The hyomandibular trunk pierces the hyomandibula and separates into the ramus mandibularis facialis and ramus hyoideus Before the trunk passes through the hyomandibula two nerves escape from it. The *ramus opercularis* (II 1 & III r.op.) courses posteriorly and supplies the operculum and the muscles adductor operculi, levator operculi and dilator operculi. The other nerve is slender which runs anteriorly innervating the muscle adductor mandibularis first.

The *ramus mandibularis facialis* (II 1 III & IV 1 r.md. fc.) runs over the preopercular bone and piercing it takes a turn downward into the lower jaw It passes the quadrate and angular bones and comes on the inner side of dentary where it runs along the outer side of muscle pars-lateralis lying above all the branches of ramus mandibularis trigemini. At the tip of the lower jaw it separates into two branchlets, which supply the lower lip and mandibular teeth. All along its course it supplies the operculo-mandibular canal of lateral-line system

The *ramus hyoideus* (II 1 III IV 1 r hy) pierces the preopercular bone and takes a course along the base of branchiostegal membrane. The nerve gives branchlets to the overlying skin and the hyohyoideus and inter hyoideus muscles.

The *ramus lateralis accessorius* (I r lat.ac.) originates from the innerside of trigemino-facial complex rising up on the side of the acustic tubercle and

cerebellum. It pierces the supraoccip tal bone and travels backward along the side of occipital crest serving as a collector of the dorsal rami of spinal nerves.

The *nervus acusticus* (III n.ac.) originates from the ventral side of medulla oblongata as broad root, which at once splits into an anterior vestibular branch and a posterior saccular branch. The *vestibular branch* goes outward dividing into many branchlets in a fan-like fashion which supply the utri culus and the anterior ampulla of sem circular canal The *saccular branch* extends posteriorly underneath the medulla and divides into two branchlets, one supplying the sacculus and the posterior ampulla of semicircular canal and the other innervating the lagena and sinus endolymphaticus

The *nervus glossopharyngeus* (I III IV 3 glp) arises by two roots from the ventro-lateral side of medulla oblongata. The two roots combine and the nerve emerges through its foramen in the exoccipital bone. The nerve turns backward and then forward in the direction of the first gill After giving a cutaneous branch to the skin of gill a pharyngeal branch to the pharynx and a branch to the muscle levator arcus branchialis the nerve runs along the anterior border of gill. It supplies the branchial lamellae along this face.

The *nervus vagus* (I II IV 3 vg n) originates by two roots from the side of the medulla. Both the roots unite and the main nerve comes out of the cranium through the vagus foramen in exoccipital Soon after its emergence the nerve separates into four branchiales, a visceralis and a lateralis. Each branchialis extends laterally and after giving off a branch to the muscle levator arcus branchialis separates into a delicate ramus pretrematicus and a stout ramus posttrematicus.

The *ramus pretrematicus* (I r pt. br 1-4) gives a pharyngeal branch to the roof of pharynx, and enters the posterior wall of the gill. The *ramus post trematicus* (I r pt. t. br 1-4) gives a thin branchlet to the muscle interarculis dorsalis and enters the anterior border of the succeeding gill. In the gill t gives a fine twig to the skin of the gill and supplies the anterior lamellae of gill.

In this manner the first, second, third and fourth branchiales innervate the first, second, third and fourth gills The posttrematic branch of the fourth branchialis, however supplies the mucous membrane of branchial cavity

The *ramus visceralis* (I III & IV 3 r visc) escapes from the vagus nerve posterior to all the branchiales. It runs for a short distance with the fourth branchialis, and then divides into an anterior and a posterior branch. The anterior branch goes ventral to the gills and supplies the heart and pericardium, while the posterior branch enters the body cavity and innervates the alimentary canal, and air bladder by its branchlets.

The *ramus lateralis vagi* (I II & IV 3 r lat. vg) is the most prominent branch which overlaps in its early course the origin of other branches of vagus

nerve. It runs backward and reaching the lateral line canal runs along it to the posterior end of the body supplying the sense organs of lateral line.

Discussion

The nervus olfactorius is slender and small in *Pararilurus* (Atoda-1936) and *Wallago* (Sinha 1956) where the olfactory lobe is close to the nasal sac. It is well formed in *Lampanyctus* (Ray 1950) and *Scomber* (Allis-1903) owing to the lobe being close to the cerebrum. In *Mystus* a condition similar to *Parasilurus* and *Wallago* (Sinha 1956) exists.

The nervus trigeminalis and nervus facialis fuses into the trigemino-facial complex in Teleosts. There is, however a variation in the number of its roots. A single root has been mentioned in *Menidia* (Herrick 1889) and *Amia* (Allis-1897) a double root in *Scomber* (Allis-1903) and two trigeminal and three facial roots in *Squalus* (Norris & Hughes-1920) and Elasmobranchs (Landacre-1916) In *Mystus* only one root has been made out like *Parasilurus* (Atoda-1936) and *Wallago* (Sinha 1956)

There is a common trunk of the ramus ophthalmicus superficialis trigeminalis and ramus ophthalmicus superficialis facialis in Elasmobranchs, while the two rami are usually separate in Teleosts. In *Wallago* (Sinha 1956) and *Parasilurus* (Atoda 1936) the two rami separate from suprao bital trunk inside the orbit, but in *Mystus* separate intracranially In *Menidia* (Herrick 1897) the two rami get fused and its branches supply the premaxillary teeth which are usually innervated by the branches of ramus maxillaris.

The ramus maxillaris is intimately fused with the ramus buccalis in *Squalus* (Norris & Hughes-1920) while it fuses with the ramus palatinus posterior n *Amia* (Allis-1891) The adductor mandibulae muscles are supplied by the branches of ramus maxillaris in *Menidia* (Herrick-1899) and by the branches of ramus mandibularis trigemini in *Scomber* (Allis-1903) *Parasilurus* (Atoda 1936) and *Lampanyctus* (Ray-1950) The branches of ramus mandibularis in *Menidia* (Herrick 1899) innervate the intermandibularis and geniohyoideus muscles, which are innervated by the branches of hyomandibular trunk in the fishes under discussion In *Mystus* the ramus maxillaris and buccalis separate intracranially but they anastomose under the eye through a connecting branch The adductor mandibulae muscles are innervated by the branches of the ramus mandibularis trigemini and the intermandibularis and geniohyoideus muscles by branches from the hyomandibular trunk.

A single ramus palatinus is present in *Lampanyctus* (Ray-1950) which splits up into an anterior and a posterior branch in *Amia* (Allis-1897) *Mystus* resembles *Parasilurus* (Atoda-1936) and *Wallago* (Singh-1956) in having two distinct rami an anterior and a posterior palatini The anterior arises from the infra orb tal trunk and the posterior from the hyomandibular trunk.

The nervus glossopharyngeus arises by a single root in *Scomber* (Allis-1903) and *Lampanyctus* (Ray 1950) while it has a double root in *Ameiurus* (Herrick 1901) *Parasilurus* (Atoda-1936) and *Wallago* (Sinha 1956). In *Scomber* (Allis-1903) a Jacobson's anastomosis between this nerve and the nervus facialis and the pretrematic branch has been mentioned, which is absent in other fishes. In this respect *Mystus* resembles *Parasilurus* (Atoda 1936) *Lampanyctus* (Ray 1950) and *Wallago* (Sinha 1956).

The nervus vagus arises by several bundles in *Scomber* (Allis-1903) and *Squalus* (Norris & Hughes-1920) and by a single root in *Menidia* (Herrick 1899) and *Lampanyctus* (Ray 1950). In *Chimaera* (Cole-1896) all the branchial rami and the visceralis have separate origin from the medulla. In *Mystus* the nervus vagus arises by double root like *Parasilurus* (Atoda 1936) and *Wallago* (Sinha-1956).

The ramus lateralis vagi issues separately from the vagus nerve in *Scomber* (Allis-1903) *Lampanyctus* (Ray-1950) *Menidia* (Herrick 1899) and *Parasilurus* (Atoda-1936) and forms a large ganglion extracranially from which various lateralis branches arise. *Mystus* resembles *Wallago* (Sinha-1956) in having a common origin of the ramus lateralis vagi and the vagus nerve. In *Wallago* (Sinha-1956) the lateralis vagi issues from the main vagus trunk, before its separation into the branchiales and visceralis. In *Mystus* it diverges from the main trunk about the level of its separation into the branchiales and visceralis.

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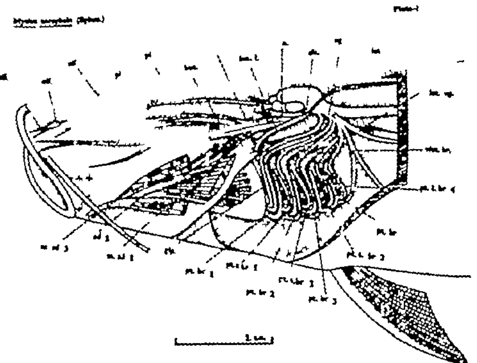
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Plate I



Side view of the cranial nerves

gl.ph., glossopharyngeus; *hm t.*, hyomandibular trunk; *i. o. t.* infraorbital trunk; *m.a.d.* 1 2 and 3 muscl adductor mandibularis one two and three; *olf l* olfactory lobe; *olf.n.*, nervus olfactorius; *olf tr* olfactory tract; *pt.br* 1-4 pretrematic branches of first second third and fourth branchiales *pt. t. br* 1-4 posttrematic branches of the first, second, third and fourth branchiales; *buc* ramus buccalis; *lat.* ramus lateralis accessorius *pl.a.* ramus palatinus anterior *pl.p.* ramus palatinus posterior *lat. vg* ramus lateralis vagi; *t.*, supraorbital trunk *tf.*, trigeminofacial complex; *vg.n.*, nervus vagus; *vac br* lateralis branch of nervus agus.

Mystus seenghala (Sykes)

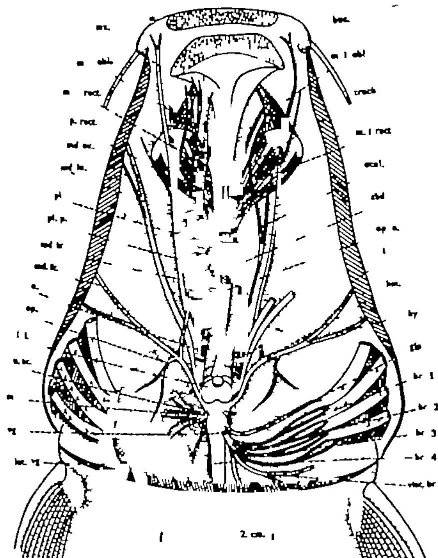
Plate-II

1

2

Fig. 1 Side view of the cranial nerves Fig. 2 Eye muscle nerves.

abd nervus bducens *bl* cerebellum *cbm* cerebrum *hm.t* hyomandibular trunk; *i.o.t.* infra orbital trunk *m.ad* l muscle adductor mandibularis one; *m.a.rect.* muscle anterior ectus; *m.i.obl* muscle inferior blique *m. rect.*, muscle inferior rectus *m.p.rect.*, muscle posterior ectus *m. obl* muscle superior blique *m. rect.*, muscle superior rectus; *mx.bl.* maxillary barbel *ocul.*, nervus oculomotorius *ocul* inferior branch of the nervus oculomotorius *ocul* superior branch of the nervus oculomotorius *olf.tr* olfactory tract; *opt.* nervus opticus *opt l* optic lobe *hy* ramus hyoideus *md.ex* mus mandibularis externus *md* amus mandibularis internus *md.fc* ramus mandibularis facialis *md.tr* ramus mandibularis trigemini *mx* mus maxillaris *op* ramus opercularis; *pl.a.* ramus palatinus anterior *pl.p* amus palatinus posterior *oph.fc* ophthalmicus superficialis facialis *oph.tr* ophthalmicus superficialis trigemini; *s.t* supraorbital trunk; *troch* nervus trochlearis



Ventral view of the cranial nerves

abd., nervus abducens *br* 1-4 branchiales first, second, third and fourth of nervus vagus; *glp* glossopharyngeus *hm. t.*, hyomandibular trunk *i. t.*, infra orbital trunk *l* inferior lobe; *m.a.rect.*, muscle anterior rectus *m i.obl.*, muscle inferior oblique *m.i. rect.*, muscl inferior rectus; *m.p. rect.*, muscle posterior rectus *m. obl.*, muscl superior oblique *m.o.*, medulla oblongata *n.ac.*, nervus acusticus; *ocul.* nervus oculomotorius *op n.*, nervus opticus *buc* ramus buccalis *hy* ramus hyoideus *lat. vg* ramus lateralis vagi; *md ex* ramus mandibularis externus *md fc.* ramus mandibulari facialis; *md.i* ramus mandibularis internus *md.tr* ramus mandibularis trigemini *mx.*, ramus maxillaris; *op* ramus opercularis *pl* ramus palatinus anterior; *pl. p* ramus pala inus posterior *s.t.* supraorbital trunk *troch*, nervus trochlearis; *vg.n.* nervus vagus *visc.br* visceralis branch of nervus vagus.

Mystus seenghala (Sykes.)

Plate-IV

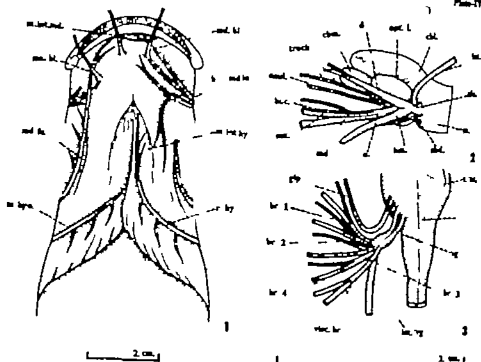


Fig. 1 Ventral view of the cranial nerves of lower j w

Fig 2 Side view of the brain showing the origin of trigemino-facial complex.

Fig 3 Ventral view of the brain showing the origin of the nervus glossopharyngeus and nervus vagus.

abd., nervus abducens; *br* 1-4 first, second, third and fourth branchiales of nervus vagus; *b.r.md i.*, branches of the ramus mandibularis internus *cbl.*, cerebellum *chm.*, cerebrum; *glp* nervus glossopharyngeus *hm t.*, hyomandibular trunk *i.o.t.*, infra-orbital trunk; *md.bl.*, mandibular barbel *ms.bl.*, mental barbel; *m int.md* muscle intermandibularis anterior *m.int hy* muscle interhyoideus; *m.hyo* muscl hyohyoideus; *m.o.*, medulla oblongata; *ocul.* nervus oculomotorius *opt l* optic lobe; *b.c.*, ramus buccalis *r.hy.*, ramus hyoideus *lat.a.*, ramus lateralis accessorius *lat.vg* ramus lateralis vagi; *r.md.*, ramus mandibularis trigemini *md f* ramus mandibularis facialis; *mx* ramus maxillaris; *s.o.t.*, supraorbital trunk *t.ac* tuberculum acusticum; *t.f.c.*, trigemino-facial complex *troch.*, nervus trochlearis *vg.n* nervus vagus *visc. br* visceralis branch of nervus vagus

STUDY OF POLLEN GRAINS OF SOME MEMBERS OF COMPOSITAE*

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INTRODUCTION

In recent years the importance of palynology in the study of taxonomy has been stressed by Erdtman (1952) Baker (1955) Faegri (1956) Raj (1961) etc. A considerable amount of work has been carried out in this aspect, but much still remains to be done.

The present investigation deals with the pollen grains of the following eight species of the Compositae belonging to four tribes occuring on the campus of Meerut College. The pollen grains were taken either from the fresh material or from the material previously fixed in F A. A.

Helianthoideae	*Eclipta alba* (Linn) Hook.
	Helianthus annus Linn
Anthemideae	*Chrysanthemum indicum* Linn
Cichoriaceae	*Sonchus oleraceus* Linn.
	Launea asplenifolia Hook. f
Inuloideae	*Helichrysum bracteatum* Andr
	Blumea lacera D C
	Vicoa Vestita Benth. ex. Hook. f

TECHNIQUE

For the preparation of pollen mounts different methods are adopted. The acetolysis method of Erdtman (1943 1952) involving the treatment of pollen grains with hot mixture of sulphuric acid and acetic anhydride have a destructive effect on exine. Faegri and Iverson (1950) recommend boiling of pollen grains with 10% aqueous potash. This technique is not adequate fo studying minute details, for t does not render grains completely transparent.

For making permanent preparations of pollen grains the following technique was dopted. Pollen bearing anthers were placed on a slide with a d op of egg albumen and the anther walls were torn off with the help of needles. The egg albumen was allowed to dry Two or three drops of 10 potassium hydroxide were put over the material on the slide, which was then heated slightly Potassium hydroxide was then washed completely with the help of water One or two drops of concentrated potassium chlorate solution and an equal amount of hydrochloric acid were added on the material. After about 30 seconds, minute amount of ferric chlorid was added to the mixture on the slide. After about

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one minute the mixture on the slide was washed with 70 % alcohol. The yellow solution on the periphery was completely removed with cotton or blotting paper as its presence has a destaining effect. The pollens were stained with fast-green prepared in 90% alcohol and mounted in glycerine jelly after passing through the grades of 90% and absolute alcohol.

The treatment of pollen grains with KOH was originally used by Von Post (see Faegri and Iverson 1950) Erdtman (1952) suggested the chlorination of pollen grains (if necessary) before acetolysis, by adding sodium chlorate and con hydrochloric acid to the pollen soaked in a mixture of glycerine and glacial acetic acid. It was found that the treatment with potassium chlorate and con hydrochloric acid was sufficient to render the pollen grains transparent. The usage of glycerine and glacial acetic acid was avoided. Ferric Chloride was found to help in giving a good stain to the pollen grains. Faegri and Iverson (1950) suggested that Basic fuchsin is the best stain. Different stains were used during the present study But fast-green was found to be better after the treatment described here.

For the determination of the size and shape, the device by Hyde and Adams (1958) was adopted.

OBSERVATIONS

Eclipta alba The pollen grains of *E alba* are tricolpate, spheroidal (23-24 $\mu \times$ 20.5-21 μ) (Figs. 1 3) Exine is 3 μ thick, thinning towards the pores and is tectate. The ectoexine is thicker than endoexine (Fig 4) The spines on the exine are 5.5 μ (average) high and arranged at a distance of 5 μ. The basal portion of the spine measure 2.5 μ The spines are pointed at the tip. In an axial view spines are arranged in 3 circles of 12 8 and 4 respectively (average) There are three tenuimarginate pores arranged in furrows. They have an oval outline with a diameter of 4.5 μ (Fig 5) Intine is rather thick, slightly extending to the pore.

Helianthus annus The grains are medium sized, prolate spheroidal (30-32 $\mu \times$ 29-30 μ) triporate and echinate (Figs. 6 7 9) The tectate exine is 2.8 μ thick, the ectoexine being thicker than the endoexine (Fig 8) which is further reduced in thickness at the pole and at the pores. The ectoexine bears spines of 5 μ high. Their base measures 3 μ across. They are arranged 3 μ apart and in an axial view the spines appear in 4 circles of 15 12 5 and 1 respectively (average) The tenuimarginate pores are 3 in number and are ellipsoidal in outline. Intine is thin.

Chrysanthemum indicum The grains are rather small, spheroidal (26-26.5 $\times$ 28-28 μ) tricolpate and echinate (Figs. 10-12) The tectate exine is 2.8 μ thick, the endoexine being thicker than ectoexine (Fig 13) The spines on the exine are small (1 25 μ high) The basal width of the spines, are 1 μ across and arranged 2.5 μ apart. The number of spines between two pores in a poler view

is 6-7 The three pores are arranged at a distance of 22-23 μ. The pores show an oval shape with a maximum width of 7 μ. Intine is thick and protrudes over the pore.

Launaea asplenifolia The pollen grains are tricolpate, prolate spheroidal (28-30 μ × 27 28 μ) and rather small (Figs. 14-16) Exine is 3 7 μ thick and tectate. The endoexine is thinner than ectoexine. The ectoexine carries two types of spines.

1 Blunt spines which are arranged one each on either side of the po e. They are 4.5 μ high The base is 5 μ wide (Fig 17)

2 Shorter spines are 2 μ high, and 1.5 μ wide at the base and arranged at 2 μ apart. There is an inner row of spines, which are arranged in a semi-star form in polar view (Fig 17) Pores are 3 in number arranged at 17 18 μ apart. The pores have a th ck exinous ring around, and are circular with a lumina of 5 μ in diameter Intine is thin

Sonchus oleraceus The grains are medium in size sub-prolate (37.5-38 μ × 33.5-34 μ) tetraporate and echinate (Figs. 18-20) Exine is 3.5 μ thick with the ectoexine thicker than endoexine The ectoexine carries two types of spines.

1 Bigger spines with broader base with abruptly ending tip. The height of these spines are 5-6 μ and the basal measurement is about 5 μ (Fig 21)

2 Smaller spines are of 7 9 in number in between two pores, in an axial view They are 1 μ high and arranged at 2 μ apart. The second ow of smaller spines are arranged in a star shaped manner Pores are arranged at 20 μ apart in a crosswise manner The pores are oval in outline. Intine is th ck at the pore, while t is rather thin at other portions.

Helichrysum bracteatum The grains are rather small, spheroidal (26-27 μ × 26-25 μ) and tricolpate, and echinate (Figs. 22 24) Exine is 2.8 μ thick. The endoexine is much thinner than ectoexine (Fig 25) Extoexine carries pointed spines. They are 3-3.5 μ high and 1 μ broad t the base, and are arranged at 3.5μ apart. The axial view shows the spines in 4 circles of 12 9 5 and 1 respectively (average) The three pores are arranged at a distance of 17 19 μ The pores are reniform (Fig 26) Intine is thin.

Blumea lacera The pollens are small and spheroidal (22-22.5 μ × 20-20.5 μ) (Figs. 27 29) They are tripo ate and echinate. Exine is 2 μ thick except at the poles, where the thickness of the exine is comparatively more. The two outermost rows of spines are alternatively arranged (Fig 30) The endoexine is thicker than ectoexine. The spines are 2 μ high with a basal width of 1 4 μ and are arranged at a distance of about 6 μ The inconspicuous pores are arranged in the same plane, located at about 20 μ apart. Intine in *Blumea lacera* is thin.

Vicoa sessilis The grains are tricolpate, rather small, prolate spheroidal (19-20 μ × 20-21 μ) and echinate (Figs. 31 32 & 34) Exine is 2 8 μ thick with the ectoexine is as thick as endoexine (Fig 33) The spines of exine are 4.2μ high and 2 2.5 μ wide and are arranged 3.5 μ apart. The spines are in 4 circles constituted by 15 12 7 and 1 respectively (average) The spines in between two pores in a polar view vary from 4-6 The three pores are arranged in furrows, at a distance of 15-18 μ The oval pore measure to 8-9 μ × 6-6.5 μ

Compound grains were observed in this species, the maximum number of grains noted in a compound grain is 12 These are perhaps formed by lying the products from more than one microspore mother cell in a common envelope (Fig 35)

Conclusions

It is not possible to make any general comments on the basis of such a meagre study It is however interesting to note that the pollen grains of different species belonging to the same tribe show uniformity in their characters, while those of different tribes differ markedly in certain respects like size and shape, thickness of exine shape, size and arrangement of spines, etc. For instance, in Helianthoideae the pollen grains are small to medium sized having narrow elongated spines In Cichoriaceae the exine is comparatively thick with limited number of larger spines with broader base, and innumerable small spines arranged in stellate fashion, whereas in Inuloideae the pollen grains are small spheroidal or subspheroidal adorned with medium sized spines with broader base and pointed tips.

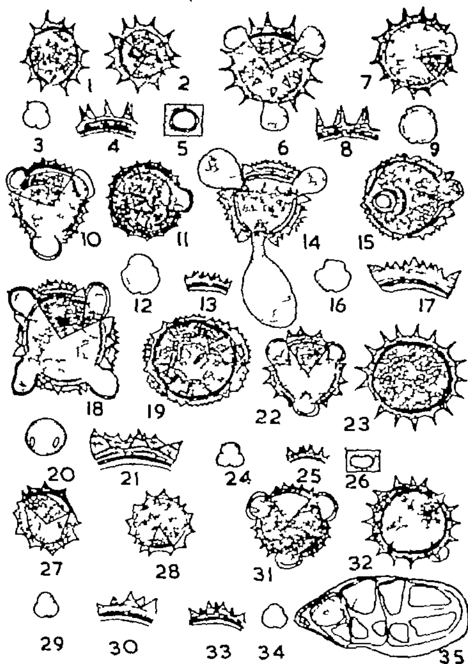
Erdtman (1952) described the pollen grains of *Helianthus annuus* as having the measurement of 34 × 38 μ. But the pollen grains of the same species studied by me showed a measurement of 32 × 30 μ only This difference may be due to some ecological or genetic factors.

Summary

This paper suggests a modified technique for the preparation of permanent mounts of pollen grains for the study of the nature of their walls. Pollen grains belonging to eight species of four tribes of Compositae are described. The salient features among the species belonging to the same particular tribe are also compared.

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Explanation of Figures

Figs 1 35 Pollen grains of Compositae. Figs. 1 5 *Eclipta alba.* Fig 1 Polar view X 429 Fig 2 Equatorial view X 429 Fig 3 General outline showing the position of the pores X193 Fig 4 A portion of the exine X 643 Fig 5 Outline of the pore X643 Figs. 6-9 *Helianthus annuus* Fig 6 Polar view X 429 Fig 7 Equatorial view X 429 Fig 8. A portion of the exine X 643 Fig 9 General view showing the position of the pores X 193 Figs 10-13 *Chrysanthemum cristatum.* Fig 10 Polar view X 429 Fig 11 Equatorial view X429 Fig 12 General outline X 193 Fig 13 Portion of exine X 643 Figs. 14-17 *Launaea asplenifolia.* Fig 14 Polar view X 429 Fig 15 Equatorial view X429 Fig 16 General outline X193 Fig 17 Exine X643 Figs. 18-21 *Sonchus oleraceus.* Fig 18 Polar view X 429 Fig 19 Equatorial view X429 Fig 20 General outline X193 Fig 21 A portion to the exine X643 Figs. 22-26. *Helichrysum bracteatum.* Fig 22 Polar view X 429 Fig 23 Equatorial view X 429 Fig 24 General outline X 193 Fig 25 Portion of the exine X 643 Fig 26 Outline of the pore X 643 Figs. 27 30 *Blumea lacera.* Fig 27 Polar view X429 Fig 28 Equatorial view X429 Fig 29 General outline X193 Fig 30 A portion of exine X643 Figs. 31 35 *Vicoa indica* Fig 31 Polar view X 429 Fig 32 Equatorial view X429 Fig 33 Exine ornamentation X 643 Fig 34 General outline X193 Fig 35 "Compound pollen grain X429

(Note the development of the germtubes in Figs 6 and 14.)

A SURVEY OF THE MARKET QUALITY OF TABLE EGGS IN AGRA TOWN

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India, striving hard to build up her national health has to undergo a revolutionary transformation with regard to its traditional concepts about human nutrition. She has to find out and develop some nutritional resources to cope up with the increasing demands of the expanding human population. Amongst the numerous kinds of dietary proteins of animal origin, milk occupies the superior most position and as such nothing would have been better than to cultivate more milk for the purpose. But our present policy of non-discrimination between good and bad and the ban on cow slaughter based primarily on sentiments rather than on reason, have closed this chapter almost for ever and it is hardly possible to riggle out of the prevailing situation As such poultry which endeavours to satisfy both the needs of nutrition and demands of the situation, becomes a subject of untold interest and consideration both by the producer and consumer

Besides quality meat, poultry produces eggs which carry comparatively little or no sentiments attached for being incorporated in the diets by a large number of people Since vast majority of eggs produced go for table purpose, their quality plays a significant role in egg trade in particular and poultry industry in general It would therefore b worthwhile to focus our attention on egg quality as it appears in the markets and to make suggestions for its improvement

The egg quality embodies the combined criteria of an egg which increase the market value to the producers, the keeping qualities to the distributors and the nutritive and the eye-appeal value to the consumers A good quality egg should have a normal shape a clean smooth and sound shell and its internal contents should have desi ed characteristics and be free from faults Its air space should be small and yolk centrally located and only faintly visible when candled. On breaking the egg the yolk should have a uniform colour and stand up forming a dome well n the centre of a compact layer of firm albumen. The latter should have a good height and cover a smaller area with an even outline The contents should show n sign of embryo development and be free from any objectionable odour or foreign matter

REVIEW OF LITERATURE

The egg quality control is relatively a newer concept in poultry science and as such considerable amount of work has been initiat d on the vario aspects of egg quality and a number of critical revie s by several worker

have appeared during the last few decades. Of the people, who have devoted themselves to the various aspects of egg quality reference may be made to Hadley et al. (1920) Atwood (1923 and 1926) Jull (1924) Hays (1929 1930 1934 and 1944) Marble (1931) Jull et al. (1933) Funk et al. (1934) Clark (1940) Jeffrey (1938) Roberts (1952) and Saito et al. (1956) with regard to egg size and weight to Godfrey (1949) Culton et al. (1952) Stadelman et al. (1953) Brooks et al. (1955) Grimminger et al. (1955) and Saunders (1956), for shell strength and colour to Lorenz et al. (1934) Van Wagenen et al (1935) Knox et al (1940) and Mayfield et al. (1949) about egg white and yolk and to Benjamin (1920) Krishnan (1943) Berry (1949 and 1950) and Rice (1950) regarding egg quality in general.

Further the various egg abnormalities and spot defects have received due attention of Roberts et al. (1929) Nalbandov et al. (1941 1944 and 1947), Card et al (1944) Jeffrey (1945) Jensen et al. (1952) Stadelman et al. (1953) and Dawson et al. (1955) while the effects of different environmental factors including feed, season temperature and age on egg quality have been illucidated by Lorenz et al. (1936) Culton et al (1952) Rosenberg et al. (1952) Gonjales et al. (1953) Jull (1954) Grimminger et al (1955) and Sauter et al. (1955) A good number of people on the other hand have also devoted themselves to keeping and conserving aspects of egg quality (Moore et al. 1945 Dawson et al., 1951 Collier 1956 and Patil, 1958)

Methods and Material

The true measure of egg quality lies in its acceptability as food or its *functional properties when incorporated with othe foods. This can be* checked to a reasonable extent by the apparent characteristics of the egg or of its contents and also by studying their chemical and biological qualities and the functional properties. In this investigation only the apparent criteria have been employed for describing and judging the egg quality as under —

1. Shell Appearance and Grading
2. Candled Appearance.
3. Broken out Appearance.
4. Hard-cooked Appearance.

This study is based on observations made on 5 000 eggs—4 000 procured from the wholesale dealer in Agra town and 1 000 from the Government Poultry Extension Unit B R. College Farm Bichpuri Ag a The procedure consisted in vis ting the important wholesale shops and picking up the desired number (25 to 50) at random and bringing them to the laboratory for detailed examination. These were then serially numbered examined for the external appearance and weighed in a torsion balance. Their internal quality on the other hand was checked by candling w thout breaking them and they were graded into f ur categories after th method of U S Standards for the candled appearance

The broken out appearance was studied only on 5% eggs selected at random. A horizontal platform of glass plates sandwitching a metric graph conveniently marked was devised for the purpose The eggs were cracked at their broader ends, the shell and shell membranes removed and the contents carefully rolled out in the centre of the platf rm. The areas covered by thin white thick white and the yolk were noted and the widths and heights of the latter two were also recorded with the help of calipers and Spherometer (Plate 1) The intensities of the yolk colour were recorded in absolute terms as light medium and dark. Egg shells were also weighed in order to determine the edible and the non-edible portions of eggs studied for the broken out appearance. A small piece of shell, taken from the broader end of the egg, was used for recording the shell thickness (Plate 2)

For the hard-cooked appearance, another 5% eggs were picked up at random and boiled in water for 5 minutes After cooling these were carefully pealed off their shells and the shell membranes and then horizontally sectioned at about 3/4th of the distance from the narrower end. The size of the air cell depression, position and colour of the yolk were recorded.

Experimental Findings and Discussion

All the observations recorded during this investigation were checked into the respective proforma developed after the recommendations of the U.S Standards for egg quality The data for each characteristics obtained have been statistically treated, graphically represented tabulated and discussed in the following pages Wherever possible, the necessary photographs have also been included in support of the text.

I Shell Appearance and Grading

External appearance of the eggs is considered to be one of the fairly accurate basis of checking for the apparent egg quality This embodies—egg size, shape, colour and the shell or any apparent abnormality which may be elaborated as under :—

1 *Egg size and Grade*—Since size and weight play a major role in the determination of market grades of eggs it is most important in determining the price for the consumers and the profits for the producers. Egg grading on the basis of size and weight, therefore, finds its due place in the egg quality studies

The size of an egg is obviously determined by the collective weights of its component parts. The observations on eg[illegible] l by different flocks have indicated that the white contributes [illegible] 58% [illegible] lk about 31 % and the shell approximately 11% of the t[illegible] ight. [illegible] weight of the white and shell depends on the area [illegible] f the part or parts of the [illegible] th [illegible] Further the small size of p[illegible] du[illegible] [illegible] of major importance, [illegible] size of the yolk and the same [illegible] re is also

known to be affected by the position of the egg in a clutch as each succeeding egg in the clutch usually shows a progressive decrease in weight (Jull 1951)

The individual egg weights as recorded during the course of this investigation average out to 38 89 ± 1 13 gm. for the market and 56·05 ± 0·24 gm for the farm eggs indicating that the latter are significantly heavier than the former (P < 0·01) Their mode of distribution in the market and the farm eggs is diagramatically shown in figure 1

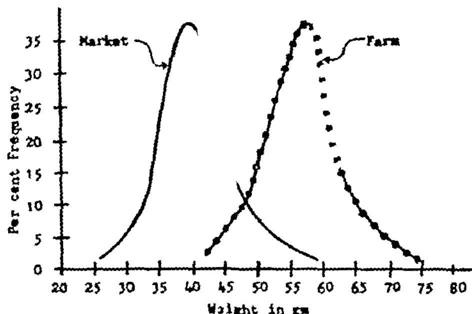


Fig. 1 Frequency distribution of egg-weight in the Market and F rm Eggs.

The average egg weight (56 05 ± 0·24 gm.) produced by the farm birds (White Leghorn) compares fairly superior to that (50 11 gms.) given by Saito Yamada and Oagwa (1956) for the same breed. The individual eggs were also graded after the method of the U S Standards using the 6 grade system as per details given in table 1 and shown in Plate 3

TABLE 1

Showing the Egg Grades of the Market and Farm Egg (per cent)

S No.	Egg Grade	Market	Farm
1	Jumbo (65 gm. or more)	0 00	11 60
2	Extra large (60 to < 65 gm.)	0 25	35 30
3	Large (50 to < 60 gm.)	4 50	45 60
4	Medium (45 to < 50 gm.)	11 80	5 00
5	Small (35 to < 45 gm.)	65 45	2 50
6	Peewee (< 35 gm.)	18 00	0 00
	Total	100 00	100 00

2. *Egg Shape*—The egg shape has no economic importance and can be easily controlled by selection It controls the preference of the consumer and the retailer because the mal-shaped eggs are more likely to be undesirable and break during transit. It is also reported that the mal-formed eggs do not have a good fertility and hatchability (Kumanon, 1948) What actually controls the shell shape of the egg and where and how is not properly understood. According to Asmundson (1931) the egg shape is determined by several factors including the amount of albumen secreted by the oviduct its lumen and the muscular movements. Four principal egg shapes (Plate 4) were recorded during the course of this investigation and the percentage distributions of both market and farm produced eggs under the same have been shown in table 2.

TABLE 2

Showing the distribution of Egg-shape in the Market and Farm Eggs (per cent)

Sl. No.	Egg Shape		Market	Farm
1	Normal		91 25	92 50
2	Abnormal			
	(a) Elongated		3 20	3 40
	(b) Spindle		2 40	2·00
	( ) Round		3 15	2 10
		Total	100 00	100 00

It is clear from table 2 that the eggs from the two sources do not differ much in shape. It was also noted that most of the breakage during the experiment, was sustained by the abnormally shaped eggs, most probably because they could not be evenly set along with the normal ones The different retail shop-keepers also informed that consumers p efer normal shapes to the abnormal ones

3 *Egg Colour*—The egg shell colour is primarily a breed characteristic and has nothing to do with the egg contents or its table value and as such the egg shell colour should have no economic or preferential val e Never theless the colour is known to affect the consumers demand. It is reported that the brown shelled eggs are preferred to the white ones in the foreign countries (Saunders, 1956) The colour choice operates in our country also In Agra and its suburbs, consumers prefer white shelled eggs to the brown ones. The reasons for preferring any particular shell colour are not quite sound and scientific. It is a matter of individual ch ice.

During the course of this study four quite distinct egg shell colou s—white, creamy light brown and brown were recorded (Plate 5) The percentages of their distribution between the market and the farm produced eggs have been presented in table 3

TABLE 3

Showing the distribution of Egg-shell Colour in the Market and Farm Eggs (per cent)

S N	Shell Collour	Market	Farm
1	White	36 05	91 60
2	Creamy	42 20	8 40
3	Light brown	21 40	0 00
4	Brown	0 35	0 00
	Total	100 00	100 00

A wide range in the shell colours of the market and the farm eggs is obvious from table 3 Such a wide variation may be assigned to the heterogenity amongst the country birds feeding our markets, as against the uniformity amongst the farm birds (all white Leghorn) It was also observed that the white shelled eggs sustained a comparatively more breakage than the brown shelled ones most probably because of their larger size and comparatively thinner shells.

4 *Shell Abnormalities*—Of the external egg characteristics shell abnormality is the most important for both the consumers and the sellers. The soiled, cracked and leaking eggs fetch lower price to their sellers and might be a source of disease and infection to their consumers. Shell abnormalities were recorded under the five heads calcified spots, soiled, stained, cracked and leaker (Plate 6) These abnormalities deteriorate the egg quality in a variety of ways. Stains, beats dirt, dust and the adhering debris make the eggs unattractive, while the cracked and leaking shells arouse the suspicion of being infested with disease producing organisms. Quite a good percentage of the eggs develop these abnormalities only after they have been laid by the birds due to improper housing and faulty handling The information obtained in the course of this study has been summarised in table 4

TABLE 4

Showing the Egg Shell Appearance of the Market and Farm Eggs (per cent)

S No	Shell Abnormalities	Market	Farm
1	Calcified Spots	2 10	4 40
2	Stained	10 00	1 00
3	Soiled	61 30	31 20
4	Cracked	3 25	4 40
5	Leaker	0 15	0 10
6	Normal	23 20	58 90
	Total	100 00	100 00

From table 4 it is clear that 76 80% of the market eggs had abnormalities of one type or the other as against only 41 10% of the farm.

II Candled Appearance

Since the external appearance is not an absolute index of what is contained within the shell the test known as candling was used to measure the interior quality in respect of the following

1 *Air Cell*—Freshly laid eggs have no air cell. As the egg cools down to room temperature its contents contract more than the shell forming an air pocket at its larger end between the two cell membranes which grows further due to the loss of moisture on storage. A good quality egg should have a small and regular air cell with restricted movement and without bubbles. Bubbles indicate weak egg membranes which break apart due to rough handling and the eggs go stale. As the egg loses quality with the growth and type of the air cell, its size serves as a good indicator of its quality and is observed first in candling The size and the type of the air cell recorded during the course of this investigation are shown in table 5

TABLE 5

Showing the distribution of Air Cell Characteristics in the Market and Farm Eggs (per cent)

S No.	Air Cell	Market	Farm
	Shape		
1	Regular	96 50	95 70
2	Irregular	3 50	4 30
	Size		
1	Small (<0 5 cm.)	4 95	8 00
2	Medium (0 5 to <1 0 cm.)	50 95	85 00
3	Large (1·0 to <1 5 cm.)	37 20	5 50
4	Extra Large (>1 5 cm.)	6 90	1 50
	Movement		
1	Restricted	94 25	98 25
2	Free	4 25	1 35
3	Bubbly	1 50	0 40

It was noted that the summer eggs had larger (Plate II) more bubbly and free air cells than the winter eggs probably due to the higher temperature and lower humidity during summers than in winters.

2. *Egg White*—Condition of the albumen plays a significant role in determining the internal egg quality A thick firm white keeps the yolk well centred and, if at all, only faintly visible when candled. A poor white on the other hand is weak and watery and enables the yolk to move more freely near the shell casting a darker shadow as the egg is twirled in candling Kinds of egg-whites as seen during this study and distributed amongst the eggs from the two sources, are shown in table 6

TABLE 6

Showing the distribution of different Categories of egg white in the Market and Farm Eggs (per cent)

S. No.	Egg White	Market	Farm
	Appearance		
1	Clear	99 90	100 00
2	Bloody	0 10	0·00
	Consistency		
1	Firm	16 85	59 60
2	Weak		
	( ) Thin	56 50	30 60
	(b) Watery	26 65	9 80

It is clear from table 6 that the farm produced eggs are superior to market eggs because of their better quality albumen in majority of cases. Four cases of bloody albumen were met within the market eggs as against nil in the farm produce. It was also noted that eggs with weak and watery albumen invariably had larger air cells, many of which moved freely and some got bubbly The size of the egg had no effect on the qual ty of egg white as some of the sm ller eggs had much better quality whites than the larger ones. Our observations on this score are also supported by Knox and Godfrey (1940)

3 *Egg Yolk*—The yolk may be light or dark yellow depending upon the feed given and the individual characteristics of the hen Normally it lies in about the centre of the egg and has a specific gravity a little less than that of the albumen The conditions of the yolk recorded during the course of this investigation have been presented in table 7

TABLE 7

Showing the Egg Yolk Characteristics of the Market and Farm Eggs (per cent)

S. No.	Egg Yolk	Market	Farm
	Position		
1	Well Centred	0 85	4 80
2	Centred	18 50	45 80
3	Off Centred	80 65	49 40
	Shadow		
1	Defined	58 35	42 30
2	Undefined	40·15	57 50
3	Seeping Yolk	1 50	0 20

Well-centred and centred egg yolks did not cast a deeper shadow while off-centred did, indicating the poor egg quality in the latter case It is noted from table 7 that both the market and the farm eggs had off centred yolks in majority of the cases The market ones, however had a by far larger number than that of the farm.

The density of yolk shadow and its defined or undefined condition during candling is not only determined by albumen but also by yolk colour Deeper shadows with relatively more defined outlines of the yolk were found in eggs with relatively larger air cells indicating that storage thins down the egg whites. This leads to the hydration of the yolks and their better visibility when candled. The incidence of seeping yolks was recorded mainly in case of the market eggs where the weak yolk membranes had ruptured allowing the yolk to flow into the albumen and impart t the peculiar appearance when candled.

4 *Overall Grade and Defects*—Overall grade was assigned to an egg on the basis of the overall candled appearance of its different components, *e g* air cell, albumen yolk, shell and the abnormality on the following basis

The top quality (AA) grade eggs had clear viscous, thick and firm whites that did not allow free movement of the yolk and consequently the yolk could not be seen clearly (Plate 7) except for a very faint shadow in some cases. The air cell was 0·5 cm. or less deep and had regular shape and restricted movement. There was no indication either of blood, meat or germ spots or of mould and rots

2. *Egg White*—Condition of the albumen plays a significant role in determining the internal egg quality A thick firm white keeps the yolk well centred and, if at all, only faintly visible when candled A poor white on the other hand is weak and watery and enables the yolk to move more freely near the shell casting a darker shadow as the egg is twirled in candling Kinds of egg-whites as seen during this study and distributed amongst the eggs from the two sources, are shown in table 6

TABLE 6

Showing the distribution of different Categories of egg white in the Market and Farm Eggs (per cent)

S. No.	Egg White	Market	Farm
	Appearance		
1	Clear	99 90	100 00
2	Bloody	0 10	0 00
	Consistency		
1	Firm	16 85	39 60
2	Weak		
	(a) Thin	56 50	50 60
	(b) Watery	26 65	9 80

It is clear from table 6 that the farm produced eggs are superior to market eggs because of their better quality albumen in majority of cases. Four cases of bloody albumen were met within the market eggs as against nil in the farm produce. It was also noted that eggs with weak and watery albumen invariably had larger air cells many of which moved freely and some got bubbly The size of the egg had no effect on the quality of egg white as some of the sm ller eggs had much better quality whites than the larger ones. Our observations on this score are also supported by Knox and Godfrey (1940)

3 *Egg Yolk*—The yolk may be lght or dark yellow depending upon the feed given and the individual characteristics of the hen Normally it lies in about the centre of the egg and has a specific gravity a little less than that of the albumen The conditions of the yolk recorded during the course of this investigation have been presented n table 7

TABLE 7

Showing the Egg Yolk Characteristics of the Market and Farm Eggs (per cent)

S. No.	Egg Yolk	Market	Farm
	Position		
1	Well Centred	0 85	4 80
2	Centred	18 50	45 80
3	Off Centred	80 65	49 40
	Shadow		
1	Defined	58 35	42 30
2	Undefined	40 15	57 50
3	Seeping Yolk	1 50	0 20

Well-centred and centred egg yolks did not cast a deeper shadow while off-centred did indicating the poor egg quality in the latter case It is noted from table 7 that both the market and the farm eggs had off centred yolks in majority of the cases The market ones, however had a by far larger number than that of the farm.

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4 *Overall Grade and Defects*—Overall grade was assigned to an egg on the basis of the overall candled appearance of its different components *e g* air cell, albumen, yolk, shell and the abnormality on the following basis

The top quality (AA) grade eggs had clear viscous, thick and firm whites that did not allow free movement of the yolk and consequently the yolk could not be seen clearly (Plate 7) except for a very faint shadow in some cases. The air cell was 0·5 cm. or less deep and had regular shape and restricted movement. There was no indication either of blood meat or germ spots or of mould and rots

2. *Egg White*—Condition of the albumen plays a significant role in determining the internal egg quality A thick firm white keeps the yolk well centred and, if at all, only faintly visible when candled A poor white on the other hand is weak and watery and enables the yolk to move more freely near the shell casting a darker shadow as the egg is twirled in candling Kinds of egg-whites as seen during this study and distributed amongst the eggs from the two sources, are shown in table 6

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3 *Egg Yolk*—The yolk may be light or dark yellow depending upon the feed given and the individual characteristics of the hen Normally it lies in about the centre of the egg and has a specific gravity a little less than that of the albumen The conditions of the yolk recorded during the course of this investigation have been presented in table 7

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4 *Overall Grade and Defects*—Overall grade was assigned to an egg on the basis of the overall candled appearance of its different components e.g air cell, albumen, yolk, shell and the abnormality on the following basis

The top quality (AA) grade eggs had clear viscous, thick and firm whites that did not allow free movement of the yolk and consequently the yolk could not be seen clearly (Plate 7) except for a very faint shadow in some cases. The air cell was 0·5 cm. or less deep and had regular shape and restricted movement. There was no indication either of blood, meat or germ spots or of mould and rots

The bottom quality (C) grade eggs on the other hand had clear weak, thin and watery albumens, which allowed free movement of the yolk making it float near the shell and casting a deeper and darker shadow (Plate 10) The air cell was more than 1 5 cm. deep and varied from regular to irregular in shape and had restricted or free movement.

The intermediate grades (A & B) had the intermediat quality of egg whites, allowing the yolk to be visible only as light dark or dark shadows (Plate 8 9) the air cell remaining 0 5 cm to 1 5 cm in depth with almost regular shape restricted movement and without any apparent defect The overall candled grade distribution of the market and the farm produced eggs alongwith their defects as found during this study is given in table 8

TABLE 8

Showing the overall Candled grade and defects of the Market and Farm Eggs (per cent)

S No.	Grade	Market	Farm
1	AA	0 10	1 00
2	A	5 65	20 50
3	B	20 75	56 50
4	C	55 40	16 40
5	Defective		
	(a) Irregular Shell thickness	10 30	4 80
	(b) Blood, meat & germ spots	4 20	0 50
	( ) Blood ring	2 95	0 30
	(d) Embryos	0 50	0 00
	( ) Egg rot	0 15	0 00
	Total	100 00	100 00

It is noted from table 8, that the incidence of the irregular shell thickness (Plate 12) was significantly more in the market than the farm produced eggs. The mottling of the shell suggests an uneven distribution of the moisture in the shells that are prone to break more than the shells with uniform thickness

The blood meat and germ spots (Plate 13) were more common (4·2%) in the market than the farm eggs (0·5%) The higher incidence of these

abnormalities in case of market eggs can be explained on the basis of their better visibility on storage (Jenson Sauter and Stadelman, 1952) Season has its own effect. Incidence is greater in summer than in winters, a trend al o observed by Jensen Sauter and Stadelman (1952) It was also noted that brown eggs had higher incidence of spot defects than the white shelled eggs which has also been reported by Dawson Davidson and Sheppard (1951) and Dawson and Richardson (1953)

Blood rings appearing on the yolk as a result of the development of embryo for a few days and then dying to leave a red ring, were met within 2 95% in case of the market eggs as against 0 30 % of the farm. It was also noticed that more of the blood rings were present during summer than the winter months, and that about 0·5 % of the market eggs had well developed embryos in them. The rots and moulds of various kinds were relatively fewer and could be met within 0 15% cases only in the market eggs.

III Broken-out Appearance

Considering the fact that the candling does not offer a complete picture about the interior quality of an egg and that there are some characteristics of its contents which cannot be observed until t is opened a random sample of 5% eggs was studied for the broken out appearance to examine the chara cteristics of white, yolk, internal defects and the relative proportions of edible and non-edible portions.

The excellent quality eggs had thick, viscous and firm white spreading only little around the yolk which formed almost a dome (Plate 14) The poor quality eggs on the other hand had thin and watery albumens spreading over a larger area with yolks having flattened tops (Plate 15) The inter mediate grades had intermediate characteristics of thin and thick whites and the yolks. In some cases the yolk membranes were weak e iough to break and allow the yolk to seep into the albumen (Plate 16)

1 *Egg White*—The area of egg white mainly depends upon ts consistency and the amount in the egg The albumen index on the oth r hand represents the sum total of both the quantity and quality of thick white and is most commonly used as the indicator of the egg albumen type. It is calculated by dividing the thick albumen height by its average width (diame ter) The frequency distribution of the albumen indices as recorded during the course of this investigation are diagramatically represented in figure ? The mean values for the egg white areas, their diameters, heights and th calculated albumen indices for the eggs of the two sources are given in table 9

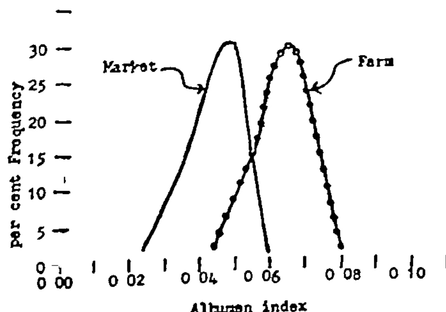


Fig. 2. Frequency distribution of Albumen Index in the Market and Farm Eggs.

TABLE 9

Showing the Mean Values of Egg-white details for the Market and Farm Eggs

S No.	Particulars	Market	Farm	Remarks
1	Thin White area (sq. cm.)	149 00±5 80	127 50±7·85	Significant P<0 05
2	Thick White area (sq cm.)	48 50±1 50	50 50±0 58	Insignificant
3	Thick White diameter (cm.)	7 89±0 34	8 01±0 25	-do-
4	Thick White height (cm.)	0 39±0 08	0 51±0 02	Significant P<0 01
5	Albumen Index	0 048±0 002	0 066±0 001	-do-

The results indicate that although the mean egg-white area and the diameter of the eggs from the two sources do not differ significantly they however differ significantly in the albumen index. The albumen index for the farm eggs works out to be significantly higher than that for the market ones This clearly indicates that the market eggs had poor quality whites.

2 *Egg Yolk*—The egg yolk colour and type are fairly good of its quality The colour of yolk is almost entirely a matter response and to some extent is also influenced by the rate of l liberal use of xanthophyll bearing feeds, such as fresh or dried-g and yellow corn, is known to result in the production of deep whereas the rations deficient in these materials produce pale The yolk colours recorded during the course of this study were l-

medium and dark. The percentage of their distribution between market and farm eggs is shown in table 10

TABLE 10
Showing the distribution of Yolk-colour in the Broken-out Market and Farm Eggs (per cent)

S. N	Yolk Colour	Market	Farm
1	Light	32 50	36·00
2	Medium	60 00	56 00
3	Dark	7·00	8 00
4	Yolkless	0 50	0 00
	Total	100 00	100·00

The yolk index is another way of designating the egg quality of the broken out eggs. It takes into account both the quality and the quantity of egg yolk and is calculated by dividing the yolk height, as it stands over the white, by the average yolk diameter Both the albumen and the yolk indices are based on the fact that the aging of eggs makes their albumens thinner and watery and the yolks to enlarge due to hydration the weak yolk membranes allowing the albumen water to enter it and make it enlarged and flattened. The frequency distribution of the yolk indices as calculated for the market and the farm eggs are diagramatically represented in figure 3

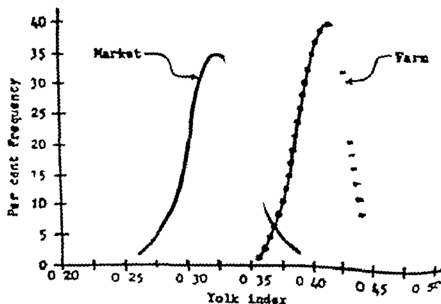


Fig. 3 Frequency distribution of yolk index in the Market and Farm Eggs

The mean values of the yolk area its diameter and height and the calculated yolk indices are given in table 11

TABLE 11

Showing the Mean Values of the Egg yolk details for the Market and Farm Eggs

S No.	Particulars	Market	Farm	Remarks
1	Yolk Diameter (cm)	4 59±0 12	4 00±0 05	Significant P<0 01
2	Yolk area (sq cm.)	14 89±0 17	12 65±0 05	-do-
3	Yolk height (cm.)	1 59±0 02	1 73±0 01	-do-
4	Yolk Index	0 32±0 01	0 41±0 06	-do-

It is clear from the figures contained in table 11 that the yolks of the farm eggs are significantly superior to those of the market in almost every respect. They have significantly smaller diameter and area more height and consequently the higher yolk index than the market ones It should therefore, be noted that the farm eggs not only have quality white and yolk but also combine their quantities a feature which is highly appreciated in the poultry enterprise.

3 *Shell Thickness*—The shell thickness primarily responsible for shell strength is of major importance in connection with egg breakage and its subsequent spoilage. The hen is expected to build an egg shell strong enough to carry its contents to the consumer without cracking under normal handling conditions. The thickness of the shell is, therefore of great importance to egg traders The frequency distribution of the shell thickness recorded during the course of this study has been graphically represented in figure 4

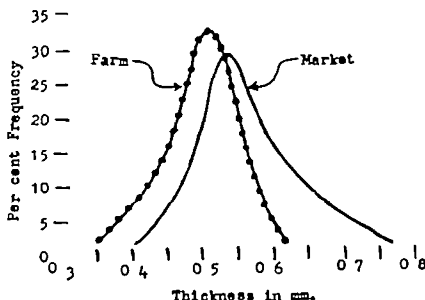


Fig 4 Frequency distribution of shell thickness in th Market and Farm Eggs.

From figure 4 it is clear that the egg shell thickness is the only feature in which the market eggs excel the farm ones It was also noted that the coloured (brown light brown and creamy) eggs had thicker shells than the white ones Similar observations have also been reported by Godfrey (1949) A thinner shell at the broader end of the egg than the narrower observed during this study is also reported by Saito Yamada and Ogawa (1956)

It is, therefore evident that the Farm eggs are more likely to crack and break during collection packing and marketing than the market eggs, a fact supported by the data (Table 4) also. The reason for the thinner shells by the farm and thicker by the country birds may be attributed to the size of the egg which they make Because the farm birds lay larger eggs with larger shell surface than the country birds their shells have to be comparatively thinner but the material for material is more in the farm eggs than the market ones as evident from the edible and non-edible portions.

4 *Edible and non-edible portions*—The amounts of edible (albumen and yolk) and non-edible (shell and shell membranes) parts of an egg are also of considerable importance The distribution of edible and non-edible portions of the egg recorded during the course of this investigation have been represented diagramatically in figure 5 and the mean values for the two portions from the two sources are given in table 12.

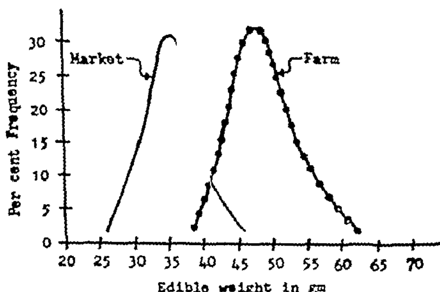


Fig 5. Frequency distribution of edible weight in the Market and Farm Eggs

TABLE 12

Showing the Mean Values of the Edible and Non-edible portions of the Market and Farm Eggs

S No.	Particulars	Market	Farm	Remarks
1	Edibl Portion (gm.)	35 48$\pm$0 71	47 32$\pm$1 23	Significant P<0 01
	(Average %)	89 13	89 26	
2	Non-edible Portion (gm.)	4 35$\pm$0 13	5 67$\pm$0 11	-do-
	(Average %)	11 12	10 73	

It is noted that while the absolute values for the edible and non edible portions of the eggs from two sources differ considerably and significantly their relative proportions expressed as percentage do not differ much. It is, therefore clear that the material for material of both ed'ble and non-edible portions is decidedly more in the farm eggs than the market ones However their ratio remains almost the same and very closely agrees with that (89 edible 11 non-edible) reported by Jull (1951)

5 *Overall Broken Out Grade and defects*—The overall broken out grades along with the various defects noted during the course of this investigation are given in table 13

TABLE 13

Showing the distribution of Overall Grades and Defects in the Broken-out Market and Farm Eggs (per cent)

S. No.	Grade	Market	Farm
1	AA	0 50	4 00
2	A	8 50	18 00
3	B	27 00	54 00
4	C	51 00	17 00
	Abnormal and Defective		
	( ) Seeping Yolk	5 00	1 00
	(b) Blood Ring	2 50	2 00
	( ) Blood & Meat Spots	4 00	0 00
	(d) Double Yolk	0 50	4·00
	( ) Egg Rots	0 50	0 00
	(f) Embryonated	0 50	0 00
	Total	100 00	100 00

IV Hard Cooked Appearance

Five per cent eggs were boiled to see some of the egg quality constants, e g position of yolk, distribution of thick white, depression of air cell colour of the yolk etc They were however categorised primarily on the basis of the yolk position, namely well centered, centered and off centered (Plate 17)

In good quality eggs, the air cell was small, the yolk was almost centrally located (Plate 23—1 & 2) and it was dark yellow to yellow in colour (Plate 18-2) The inferior and poor quality eggs had larger air cells and off centered yolks (Plate 17—3 & 4) of lighter colour (Plate 18-1)

The overall category and the various defects recorded for the hard cooked eggs during the course of this investigation are given in table 14

TABLE 14

Showing the distribution of the Overall Hard Cooked Grades and Defects in the Market and Farm Eggs (per cent)

S. No.	Grade	Market	Farm
1	AA	0 00	0 00
2	A	6 50	12 00
3	B	21 00	63 00
4	C	57 50	11 00
5	Defective—		
	( ) Cracking of Shell	10 50	12 00
	(b) Uncoagulated albumen	4 00	2 00
	( ) Embryonated	0 50	0 00
	Total	100 00	100 00

The above table indicates that quite a good number of eggs were found to be defective Cracking of the shells (Plate 19) was the commonest defect noted It was relatively more in the farm than the market eggs The obvious reason may have been the comparatively thinner shells in case of the farm eggs than the market. The reason for the uncoagulated condition of the contents is not properly understood. The only one embryonated egg with almost fully formed chick (Plate 20) was met within the market eggs during summer suggesting that either it was stored at some warm place for longer duration or stolen from a brood

In the end, to have an overall picture of the quality of market eggs in Agra City the results of this investigation have been summarised in table 15.

TABLE 15

Showing the Overall Picture of the Market and Farm Eggs in Agra Town.

S. No.	Particulars			Market	Farm	Significance Level
	External Appearance					
1	Size	Average Weight (gm.)		38 80±1 13	56 05±0 24	P<0 01
		Majority Grade		Small (35-45 gm.)	Large (50-60 gm.)	
2	Shape	Normal	(%)	91 25	[illegible] 50	
		Abnormal	( )	8 75	7 50	
3	Colour	Coloured	(%)	63 95	8 40	
		White	( )	36·05	91 60	
4	Shell	Normal	( )	23 [illegible]0	58 90	
		Defects	( )	6 80	41 10	
	[illegible] Appearance					
5	Grade	AA	(%)	0 10	1 00	—
		A	( )	5 65	[illegible]0 50	
		B	( )	[illegible]	56 50	—
		C	( )	35 4[illegible]	16 40	
		Defective	( )	18 10	5 00	—
	[illegible]					
6	[illegible] Index			0 048±0 0[illegible]	0 066±0 [illegible]	P<0·01
	Yolk Index			0 3[illegible]±0·01	0 41±0 0[illegible]	P< [illegible]01
8	Shell Thickness	(mm)		0·[illegible]± [illegible]	[illegible]±[illegible]1	P<0 01
9	[illegible]	(cm)		[illegible]± [illegible]1	4 [illegible]±	P<0·01
		[illegible] Average		[illegible]	[illegible]	
10	[illegible]	[illegible] (cm)		4 [illegible]± [illegible]13	[illegible]	P< [illegible]
		Average		[illegible]	[illegible]	—
11	[illegible]	AA	[illegible]	[illegible]	[illegible]	—
		A		[illegible]	[illegible]	—
		B	[illegible]	[illegible]	[illegible]	—
				[illegible]	[illegible]	—
		[illegible]	[illegible]			—

[illegible]

TABLE 15—(Contd.)

S. No.	Egg Particulars			Market	Farm	Significance Level
	Hard Cooked Appearance					
12	Grade	AA	(%)	0·00	0 00	..
		A	(%)	6 50	12 00	...
		B	(%)	21 00	63 00	
		C	(%)	57 50	11 00	
		Defective	(%)	15·00	14 00	...

SUMMARY AND CONCLUSION

The observations reported herein are based on the study of 5 000 eggs, selected at random to study the market quality of table eggs in Agra town. Of these 4 000 came from the dealing markets in the town and the rest from the Government Poultry Extension Unit, B R. College Farm, Bichpuri. All the eggs were examined for the external shell appearance and candling, while 5% samples from each source taken at random were used for the broken out and the hard cooked tests separately The results obtained have been diagramatically represented, statistically treated and discussed Wher ever possible the necessary photographs have also been included in support of the text

It was noted that the farm produced eggs were significantly superior to those of the market and excelled them in almost every respect except the shell thickness, which was more in the market than the farm eggs.

The farm eggs in general were uniformly sized, normally shaped and mostly white in colour with comparatively fewer shell abnormalities and weighed on an average 56·05 ± 0·24 gm. as against the market ones which had no uniformity either in size or shape or colour had plenty of shell defects and weighed only about 38·89 ± 1 13 gm.

On candling also the farm eggs revealed a better quality than the market ones They had comparatively smaller air cells thicker whites which in most of th cases did not allow the clear visibility of the yolks and the spot defects were also uncommon. The market eggs on the other hand had larger air cells thinner whites, and common spot defects Th yolks in many cases had well-defined and darker shadows.

The farm eggs in the broken out test had larger amounts of both the quality whites and the yolks than those of the market. The egg whites stood

higher around the domed yolks in the farm eggs as against the flattened yolks surrounded with low whites of the market ones.

The colour of the yolk, however did not differ significantly although there was a little more incidence of darker yolks in the farm eggs than the market.

In the hard cooked test the farm eggs again proved superior to the market ones on the basis of the air cell size, yolk colour yolk position and the defect frequency

In the end, we can safely conclude that the eggs produced under farm conditions by the improved breeds under better conditions of feeding and management are much superior to their counterparts produced by the indigenous breeds which have poor producing potential and are being inadequately fed, housed and managed. It is, therefore, recommended that for better and effective improvement of the poultry industry more and more extension units be established in the country and the masses be educated about the importance of good breeding feeding and management so that they might get better returns for their efforts and make poultry a paying proposition.

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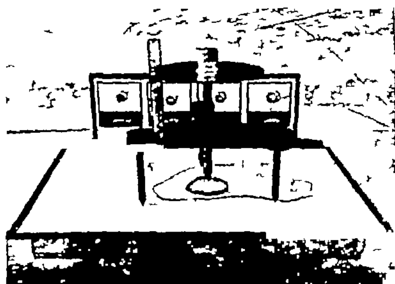


Fig. 1 Showing the method of using spherometer for recording the yolk and albumen heights.

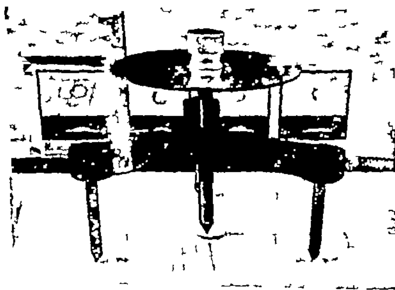


Fig. Showing the method of taking shell thickness of the egg shells



Fig 3. Showing the Egg grades, 1 Jumbo extra large 3 Large 5. Small and 6. Peewee.

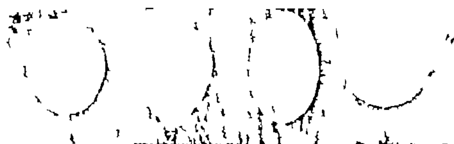


Fig 4 Showing the Egg shapes 1 Normal ... Elongated 3 ... d ...



Fig. 5 : Showing the Egg colour 1 White, 2. Creamy 3. Light brown and 4 Brown

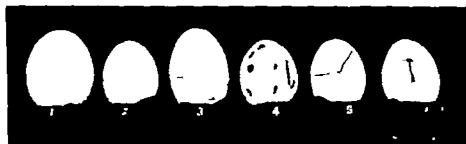


Fig. 6 : Showing the Egg shell defects, 1 Normal, 2. Calcified Spots, 3 Soiled, 4 Stained, 5. Cracked and 6 Leaker



Fig 7 Showing the candled appearance of AA grade (Top quality) egg. Not the clear content without yolk shadow



Fig. 8. Showing the candled appearance of A grade (Intermediate quality) egg Note the light yolk shadow



Fig [illegible]



Fig [illegible] Showing the candled appearance of C grade (bottom quality) egg. Note the deep dark yolk shadow



Fig. 11 Showing the candled appearance of stale egg. Note the extra large air cell.



Fig. 12. Showing the candled appearance of an egg with irregular shell thickness.



Fig. 13. Showing the candled appearance of an egg with spot defect.



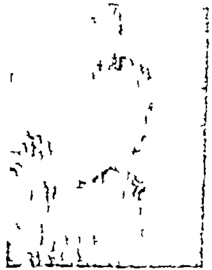
Fig. 7 Showing the mottled appearance of AA grade (Top quality) egg. Note ... ... lk h dow



Fig. 8. Showing ... ... of A gra ... ... lity) egg ... shadow



... ...



howing the ... of "C" grade ... ...



Plate 17 Showing the hard cooked sectioned appearance of eggs to show the position of the yolk. 1 Well centered, 2 Centered, 3 Off centered and 4 Adhered to shell.

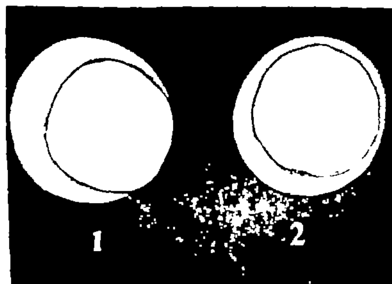
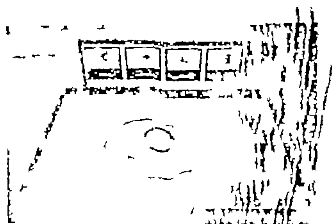


Plate 18 Showing the hard cooked sectioned appearance of eggs to show the yolk colour 1 Pale yellow yolk, 2 Deep yellow yolk.



[illegible] Showing the broken [illegible] appearance [illegible]
[illegible] the small white [illegible] and [illegible]

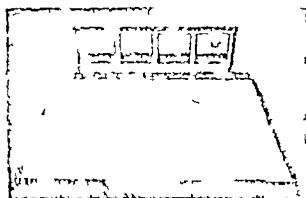


Fig. 1a. Showing [illegible] broken out appear[illegible]
[illegible] [illegible] egg. [illegible]
[illegible]



Fig. [illegible] Showing [illegible]
[illegible]



Fig. 19 Showing boiled egg with cracked shell.



Fig 20. Showing boiled embryonated egg opened to show almost fully formed chick

A NOTE ON THE MALE GENITALIA OF *BALIOPTERA ARGENTATA* (OPOMYZIDAE CYCLORRHAPHA DIPTERA)*

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INTRODUCTION

There is no work done on the genitalia of this family of illdefined limits. The present paper deals with the male genitalia of a common Indian Opomyzid, *Balioptera argentata* and is in continuation of author s earlier paper† on the thoracic morphology of the same. Account on the head sclerites and other systems will appear in subsequent papers.

My sincerest thanks are due to Dr T Singh, Professor of Zoology and Entomology School of Entomology St. John s College, Agra for providing me facilities for work. I thank Dr Santokh Singh for encouragement and Mr Santosh K. Tandon esearch colleague, for placing at my disposal the valuable material for work. Thanks are also due to Ministry of Scientific Research & Cultural Affairs for financial help

MATERIAL AND METHOD

The flies collected from the leaves of *Ageratum* sp. Botanical Garden, St. John s College, Agra during the month of November 1961 decolourised by chlorine fumes, treated with 10% cold KOH for 24 hours, alkaline effect neutralised by acetic acid, upgraded, stained with Eosin were later dissected in Canada balsam for detailed study The diagrams were drawn with the help of Camera lucida. The terminology followed here is after Van Emden and Willi Henning (1956)

The Male Genitalia (Figs. 1 2, 3 & 4)—The male genitalia formed at the apex of the male abdomen continues to be a subject of controversy among the Dipteron morphologists. Various authors call it genitalia, hypopygia, genital apparatus 1 armature genitale, armature copulatrix, geschlecht sanhange, terminalia, pygidia etc. as quoted by Metcalf (1921) In *Balioptera argentata* the genital segment is the ninth abdominal segment, a view held by Lundbeck (1916) Miyake (1919) Snodgrass (1935) Crampton (1942) Munro (1947) Ferris (1950) Van Emden and Willi Henning (1956) Nayar (1961) and Nayar and Tandon (1962) The complex male genitalia lies ventrally due to the circum versions of the hypopygia (Crampton, 1942) The eighth bdominal segment plays no part in the formation of the termi-

* Contribution No. 100 from the School of Entomology St. John s College Agra.

† Nayar J L. 1963 Thoracic morphology of *Balioptera argentata* (Opomyzidae Cyclorrhapha Diptera) *J Ani Morph. Phy* Baroda. (I Press)

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nalia. Tergal and sternal components of ninth segment are not clearly demarcated as the spiracles are lacking Metcalf (1921) however applied a term urite to a segment with indistinguishable tergum and also presumed that the complex structure behind the eighth tergum with the styles and the claws represents the tenth tergum in Syrphidae. The ninth tergum (T_9) or epandrium is trough shaped highly sclerotised structure, bearing two pairs of lateral appendages. Zumpet and Heinz (1950) and Fluke (1951) refer it as the tenth tergite in Diptera and Syrphidae respectively Lundbeck (1916) Nayar (1961) and Nayar and Tandon (1962) have however maintained that the surstyli bearing part is the ninth tergum in Diptera, which is in accord to Ferris's (1950) views in holding the first apparent abdominal segment to be in reality the second in Diptera. Berlese (1909) maintained that the first apparent abdominal segment is the third so the genital segment in Diptera is the eleventh abdominal segment. The latter's interpretations are not tenable in view of the most elaborate review work on Dipteron male terminalia by Van Emden and Willi Henning (1956) Two pairs of lateral appendages of the epandrium *i.e.* valvulae laterales (VL) and valvulae mediales (VM) are highly controversial in their terminology Each valvulus lateralis (VL) outer clasper Munro (1947) is a small claw like structure lateral to the valvulus medialis and is considered homologous to Stylus or dististylus while valvulus medialis (VM) is a long bent lobe like structure with concave inner and convex outer margins. The latter are variously called as mesostyli, appendage I claws, and forceps inferiors (Metcalf 1921) Van Emden and Willi Henning (1956) have homologued these to cerci while the author reserves the term cerci for elongated lobe-like structures borne on the interior surface of the ninth tergum, which are really representing the tenth segment (Nayar and Tandon, 1962) (In Press) The strongly bristled cerci (CRS) or the acrocerci, Berlese appendage IV Newell lamellae Lundbeck, epiproct Crampton and forceps superiors, Wesche, lie parallel to one another along their inner margin. Fluke (1951) believes them as appendages of the tenth tergite

The ninth sternite (S_9) or hypandrium forming the copulatory apparatus is a complex of (I) phallic and (II) periphallic organs.

( ) *Phallic organs*—These comprise the (a) phallobase (PHB) (b) phallotheca (PHC) or endotheca, (c) aedeagus (AED) and (d) endophallus (TNPH)

(a) *Phallobase*—or phallophore (Crampton 1942) or basal part of the phallus is a median outgrowth of the ventral wall of the hypandrium (S_9) into which lies the telescoped aedeagus. No spinus is found on the dorsal urface of the phallobase.

(b) *Phallotheca*—or endotheca is the membranous cylindrical part between the apical end of the phallobase and the basal part of the aedeagus, which enables the telescoping of the latter into the former

(c) *Aedeagus*—or 'penis proper (Fluke, 1951) or distiphallus as suggested by Van Emden and Willi Henning (1956) is a long chitinous tubular structure at the tip of the phallotheca.

(d) *Endophallus*—is a membranous hood-like structure at the distal end of the aedeagus, with the distinct genital pore (GP) in its centre. Metcalf (1921) and Fluke (1951) referred it as the ejaculatory hood.

(ii) *Periphallic organs*—These are two pairs of appendages laterad to the aedeagus *i.e.* anterior and posterior gonapophyses (AGP and PGP) arising postero-laterally from the ninth sternum (S_9) The former or the inferior lobes (Metcalf, 1921) or palps genitalia (Van Emden and Henning 1956) are small conical lobes, broad basally and narrow apically while the latter or para meres or harpes or superior lobes of workers are prominent broad lobes disto-caudal in position to the former Crampton (1942) believes that both these appendages are new acquisitions of Cyclorrhapha while Zumpet and Heinz (1950) maintain that they are the result of a division of the parameral lobes. The true homologies can only be established if the ontogenetic research on what has happened of the gonopods in Cyclorrhapha is studied. These may function as claspers during copulation.

SUMMARY

The ninth bdominal segment forms the complex male genitalia, where the ninth tergum or epandrium bears the valvulae laterales and valvulae mediales, while the sternum component or hypandrium comprises the phallic and pariphallic organs. Both have been separately discussed in detail.

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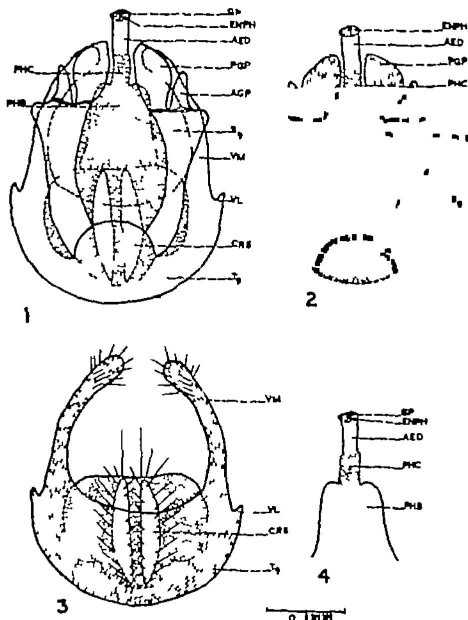


Fig. 1 Male genitalia of *Balioptera argentata* (semi-diagrammatic)

Fig. 2. Hypandrium and associated structures

Fig. 3 Epandrium and associated parts.

Fig. 4 Phallic pparatus.

AED Aedeagus *AGP* Anterior gonapophysis; *CRS* Cirrus; *ENPH* Endophallus; *GP* Gonopore *PHB* Phallobase; *PHC*. Phallotheca; *PGP* Posterior gonapophysis; S_9. Ninth sternum; *T* Ninth tergum; *VL* Valvulus lateralis and *VM* Valvulus medialis.

SENSORY CANALS AND RELATED DERMAL BONES OF THE HEAD IN *MYSTUS SEENGHALA*

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INTRODUCTION

The investigations regarding the lateral line system of Indian Siluroids are very few and thus the course of the sensory canals and related dermal bones in the head of *Mystus seenghala* have been studied.

Pollard (1892) and Collinge (1895) have described the sensory canals in a number of adult and young fishes. Allis (1904) Herrick (1901) Friedrich-Freksa (1930) and Kapoor (1960 61) in later years, have made useful contributions in the field.

MATERIAL AND TECHNIQUE

The course of the sensory canals in the head has been studied in dried skulls by inserting a piece of animal hair in the canals and also by injecting Indian Ink through the pores. The canals wherever not visible were studied by dissection under stereoscopic binocular microscope after the material had been decalcified in a mixture of 100 c.c. of 80% alcohol and 4 c.c. of nitric acid. The fishes were obtained from the local fish market of Muzaffarnagar

OBSERVATIONS

The supraorbital canal and related dermal bones—The supraorbital canal is enclosed in the nasal and frontal bones.

The nasals (na) are two long narrow tubular bones lying one on either side of the ethmoid (eth) and over the lateral ethmoid (le) They are not directly connected to the cranium but lie embedded in the connective tissue.

The frontals (fr) are a pair of flat thin bones situated between the ethmoid in front and the supraoccipital behind. The two frontals do not unite along the anterior mid-dorsal line for about less than half their length and enclose a fontanelle (f) Posterior to this the two frontals unite suturally with each other The two frontals unite anteromesially with the ethmoid and anterolaterally with the sphenotic (sph) Posteriorly the frontals unite with the supraoccipital (suo) and posteroventrally with the pleurosphenoids.

The supraorbital canal (soc) begins with a pore (s1) placed at the anterior end of the nasal which leads into a backwardly directed canal. After running for a short distance the canal opens to the outside at its inner margin by a pore borne on a small forwardly directed tube. From this point the canal

runs backward throughout the length of the nasal until it passes out of the latter and enters the frontal bone. The canal after running for a short distance in the frontal gives off a large forwardly directed tube which continues upto the anterior limit of the fontanelle and opens to the outside by means of a pore. The main sensory canal further runs backward and inward upto the middle of the posterior limit of the fontanelle and the anterior end of the supraoccipital and opens to the outside at its inner margin by two pores (c) The two pores are situated close to each other near the mid-dorsal line. The pores which are borne on separate small backwardly directed tube lie just opposite to the corresponding pores of their counterpart on the other side of the head. From this point the canal runs further backward for a short distance until it leaves the frontal bone at its posterior edge to join the infraorbital canal in the region of the sphenotic. Close to this junction of the supraorbital and infraorbital canals, the former gives off a small branch which runs backward enclosed within the frontal bone.

The infraorbital canal and related dermal bones—The infraorbital canal is enclosed in the lachrymal preorbital two suborbitals, postorbital and the sphenotic.

The lachrymal (lc) is an elongated bone with broad anterior and tubular posterior end. The anterior broad portion forms the outer lateral wall of the nasal capsule while the posterior tubular portion is loosely attached to the lateral margin of the lateral ethmoid.

The preorbital (pro) and two suborbitals (so) are long tubular bones lying one behind the other The preorbital is attached to the lateral margin of the lateral ethmoid while the suborbitals form the inferior boundary of the orbit The second suborbital is attached to the postorbital posteriorly The postorbital (po) is thin plate like bone forming the posterior boundary of the orbit It articulates posteriorly with the anterolateral margin of the sphenotic.

The sphenotic (sph) is an irregular bone situated dorsolaterally anterior to the pterotic. The sphenotic articulates anteriorly and anteromesially with the frontal, posteromesially with the supraoccipital (suo) posteriorly with the pterotic and ventrally with the pleurosphenoid and prootic

The infraorbital canal (ioc) begins with a pore (i1) situated at the anterior end of the lachrymal. It runs backwards through the lachrymal and opens to outside by a second pore (i2) borne on a small forwardly directed tube, situated near to the first pore. After running through the lachrymal the canal passes backward into the preorbital From the preorbital the canal is conducted into the first and then to the second suborbital It is further conducted to the postorbital bone. There are no pores in any of these bones. As the canal passes out from the postorbital, the canal opens to the outside by a pore (i3) From this point the canal runs backward and inward for a short distance into

the sphenotic until it finally joins the supraorbital canal and temporal canal (tc) somewhere in the middle of the sphenotic. The junction of the three canals is not marked by any pore.

The temporal canal and related dermal bones—The temporal canal is enclosed in the sphenotic, pterotic, supratemporal and posttemporal.

The sphenotic (sph) has been described in connection with the infraorbital canal.

The pterotic (pt) is somewhat rectangular bone situated in the posterior dorsolateral region of the skull. It articulates with the sphenotic anteriorly with the supratemporal posteriorly and with the supraoccipital mesially

The supratemporal (st) is a small bone behind the pterotic. It is connected by means of sutures anteriorly with the pterotic, mesially with the supra occipital and posteriorly it interlocks with the anterior end of the posttemporal.

The posttemporal (pot) is an irregular bone which interlocks anteriorly with the supratemporal and pterotic bones. Posteroventrally it gives off a forwardly directed prong which articulates with the lateral facet of the basioccipital (bo) The anterior end of the posttemporal also touches the epiotic.

The supra and infra-orbital canals join each other in the region of sphenotic and contrary to what might be expected, their junction is not marked by any pore. From this junction the canal runs backward as a temporal canal (tc) along the outer margin of the sphenotic, until it passes into the pterotic bone. The temporal canal passes from the sphenotic to the pterotic bone without opening to the outside and after running nearly half way along the outer margin through the latter it opens outside by a pore (x) to meet the preopercular canal (pc) It continues its course further backward enclosed within the outer margin of the pterotic throughout its length until it passes into the supratemporal bone. Near the suture of the pterotic and the supratemporal bone the canal opens to the outside by a pore (t 1) borne on a backwardly directed tube. The canal runs further backward along the outer margin of the supratemporal bone where it again opens outside through an another pore (t 2) F om this point the temporal canal passes from the pterotic to the posttemporal bone and finally continues backwards as the main lateral line canal of the trunk.

The mandibular canal and related dermal bones—The mandibular canal is enclosed in the dentary and angular

The dentary (dn) is a curved elongated bone carrying numerous sharp conical teeth in sockets. The two dentaries articulate anteriorly with each other along the middle line and posteriorly with the angulars of their own side.

The angular (an) is an irregular bone interlocking with the posterior end of the dentary anteriorly It bears a facet at its hinder end by which it makes an articulation with the quadrate.

The mandibular canal (mc) begins with a pore (ml) placed ventrally near the tip of the ramus of the lower jaw The pore leads into the mandibular canal, which runs backward through the entire length of the dentary and a small portion of the angular The mandibular canal of each side opens through the bone to the outside by eight po es All these pores are borne on a small backwardly directed tube which arise from the ventral margin of the main canal. Coming out of the angular bone, the mandibular canal joins the ventral end of the preopercular canal, and the junction between the two is marked by a pore (y)

The pre percular canal and related dermal bones—The preopercular canal is enclosed in the preoperculum only

The p eoperculum (prop) is a thin crescent-shaped bone placed posterior to the hyomandibular and quadrate. The dorsal end lies apposed over the posterodorsal edge of the hyomandibular while the ventral end is firmly interdigitated with the posterior process of the quadrate. The ventral edge of the bone extends close to the point of articulation of the lower jaw while the dorsal end fails to each upto the pterotic bone.

From the junction with the mandibular canal, the preopercular canal (p) runs through the entire length of the posterior ridge of the preoperculum. Along its entire course the canal opens through the bone to the outside by one pore pl) near the posterior limit of the quadrate. The canal opens at the dorsal end of the preoperculum through a pore. It joins the temporal canal at about the middle of the pterotic bone. The junction between the preopercular and the temporal canal is marked by a pore (z) The canal in between the preoperculum and pterotic runs in the dermis.

DISCUSSION

The course of the sensory canals of the head in *Mystus seenghala* broadly fits into the fundamental Teleostean plan. A comparison with other Siluroids studied by other workers shows that this fish agrees with them in all respects but a number of differences are noteworthy

The supraorbital canal in nasal has a small forwardly directed tube which opens to the outside near the anterior pore like other Siluroids. A similar branch of tube in the nasal bone has been descrided in *Chaetostomus* (Pollard, 1892) *Amiurus* (Collinge, 1895) and *Wallago* and *Heteropneustes* (Kapoor 1960,61) Collinge's (1895) statement that in *Clarias* the supraorbital canal terminates anteriorly in the premaxilla seems to be erroneous as no such connection of the canal has been reported by any worker Kapoor (1960) also denies its presence in the siluroid fishes. In *Mystus* the anterior end of the nasal reaches upto the dorsal surface of the premaxilla and looks at one glance as if the canal is present in the premaxilla. Such a connection of nasal is also stated by Nawar (1954) in *Clarias* and this might have induced Collinge to make this statement.

A commissure connection between the supraorbital has been reported in a number of Siluroids and other fishes. Pollard (1892) described a commissure connection between the supraorbital canals of the two sides in the region of frontal bones in *Chaetostomus* and in a rudimentary condition in *Clarias*. A pore tube commissure is stated to occur in *Plotosus* (Friedrich-frekas, 1930) and *Ophiocephalus* (Kapoor 1960). A vestige commissure has been recorded in *Macropterus jamaicans* (Yih 1948) and a short diverticulum in *Aphredoderus sayanus* (Moore & Burris, 1956). In *Mystus* there are two pores on either side which do not form the commissure. It may be mentioned here, however that the number of such pores in this does not always remain constant. In one of the examined specimen the canal had a single pore on each side whereas in other specimen, one pore on one side and two on the other. Kapoor (1960 61) stated a single pore on each side in *Wallago* and *Heteropneustes*

The posterior prolongation of the supraorbital canal before joining the infraorbital canal in *Mystus* can be compared with the anterior pit line of *Amia* (Allis, 1889). Lekander (1949) after studying the *Leuciscus* and *Salmo* states the way of formation in these two fishes is identical, while the final resulting *Leuciscus* is a canal in *Salmo* it is a pit line". A similar prolongation of the supraorbital canal has been described in *Wallago* and *Heteropneustes* (Kapoor 1960 61) and *Clarias* (Pollard, 1892)

The temporal canal is stated to be conducted from the pterotic to the posttemporal bone in all the silurids, previously studied. In *Mystus* a supratemporal bone has been observed in between the pterotic and posttemporal which encloses a part of the temporal canal. So far as we are aware no previous worker has reported the supratemporal bone in the course of the temporal canal in the silurids.

Pollard (1892) in *Chaetostomus* and Collinge (1895) in *Clarias* described a small ventral portion of the preopercular canal in the interoperculum. We share our view with Kapoor (1961) that the enclosure of the preopercular canal in the interoperculum is purely secondary. In *Mystus* the preopercular canal is enclosed only in the preopercular bone like *Wallago* and *Heteropneustes* (Kapoor 1960 61)

Herrick (1901) in *Ameiurus melas* has shown at one instance a small tubular ring or ossicle of bone, the supraopercular extending between the preoperculum and the pterotic. Kapoor (1961) describes a similar ossicle in *Wallago*. A similar ossicle has been described in *Salmon* (Collinge, 1893) *Leuciscus* (Devillers, 1947) and *Anguilla* (Lekander 1949). Pollard (1892) on the other hand did not report any such ossicle in *Loricaria* (?) *bucculatus* but writes "the last portion of the canal lies in the dermis outside the dilator operculae muscle". A similar condition has been observed in *Mystus*. Lekander's (1949) statement "as a rule, the preopercular canal opens in the temporal canal" seems to be correct as far as adult silurid are concerned though his observation is based on the study of young stages of some siluroids.

Summary

The head sensory canals and related dermal bones in the adult *Mystus seenghala* have been studied. The supra the infraorbital and the temporal canals join each other behind the eye. The mandibular canal is continuous with the preopercular canal and the latter with the temporal canal after passing through the dermis between the preopercular and pterotic bones A posterior prolongation of the supraorbital canal is present. The temporal canal passes through the supratemporal bone also The mandibular canal of the two sides are separate. The course of the sensory canal system in this fish has been compared with a number of silurid fishes. Such a comparison shows that it agrees with other allied forms, although there are certain individual differences.

Acknowledgements

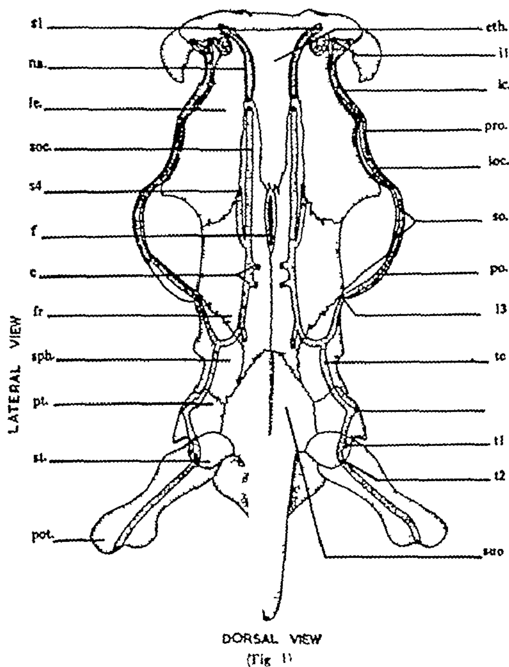
The present work has been carried out in the Zoological Research Laboratory of D A. V College, Muzaffarnagar and the authors wish to express their gratefulness to Dr V P Agarwal, Head of the Zoology Department for giving necessary research facilities.

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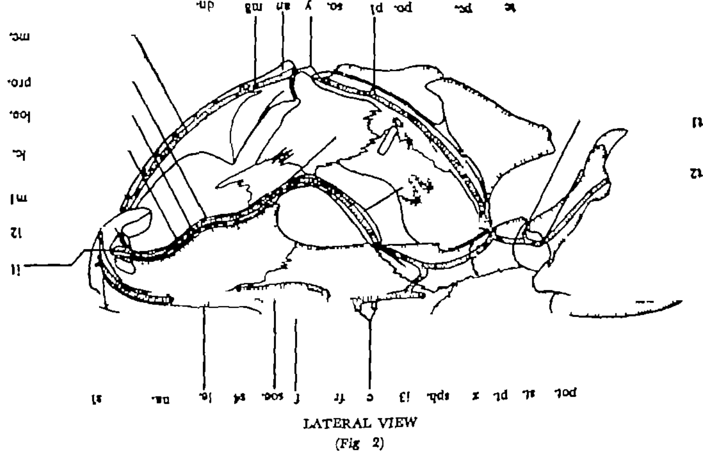
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EXPLANATOIN OF LETTERINGS

an ....angular
........................pores of the supraorbital
dn ....dentary
eth........................ethmoid
f ....fontanelle
fr ....frontal
i 1 3 ....pores of the Infraorbital canal
ioc ....Infraorbital canal
le ....lateral ethmoid
m 1-8........................pores of the mandibular canal
mc ....mandibular canal
na ....nasal
p1........................pore of the preopercular canal
pc ....preopercular canal
po ....postorbital
pot........................posttemporal
pro ....preorbital
pt ....pterotic
1-4 ....pores of the supraorbital canal
so ....supraorbital
soc........................supraorbital canal
sph ....sphenotic
st ....supratemporal
soo ....supraoccipital
t 1 2 ....pores of the temporal canal
tc ....temporal canal
y ....pore at the junction of the preopercular and mandibular canals
........................pore at the junction of the preopercular and temporal canals


s1
na.
fe.
soc.
s4
f
c
fr
sph.
pt.
st.
pot.
eth.
l1
lc.
pro.
loc.
so.
po.
l3
tc
t1
t2
suo
LATERAL VIEW
DORSAL VIEW

(Fig 1)



LATERAL VIEW

(Fig 2)

STUDIES ON THE PHYSICO-ENGINEERING PROPERTIES OF SOME TYPICAL INDIAN SOILS Pt. I

[CHARACTERIZATION OF SOME TYPICAL SOILS BY MECHANICAL ANALYSIS IN RELATION TO THEIR pF/MOISTURE CONTENT CURVES]

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INTRODUCTION

Soil moisture and the factors governing its movements are considered to be very mportant in soil stabilization for Road Construction. The question of swelling and shrinkage of the road subgrade matters a great deal for the cause of deterioration of the surface of the roads and this fact has been confirmed particularly for the roads built on a clayey s bgrade. The ther modynamics of so l moisture has given us a clue for the characterization of different soils determined by the methods of studying the relation between the moisture content and suction of held up water This suction is expressed in terms of pF against the moisture content at variable suction pressures. Schofield R. K. (Trans 3d Intern. Cong Soil Sci. 2.37-48) defines pF as the logarithm of height in centimetres of water column that is necessary to produce a desired suction and correlated it with the energy with which the water is held by the soil. Thus the determination of the moisture content of different types of soils at different suction forces shows the water holding characte ristics which mainly depend upon the percentage of clay and hence gives a suitable index to characterise the more clayey and the less clayey soils from the gradients of log Tension (or pF)/ moisture content curves. Studies in this aspect are of importance to the road engineers. W th this end in view a few typical soils of India have been investigated for the relationship of their pF and moisture content The curves are significant for the moisture retention property of the soils and its relation to the clay percentage from the viewpoint of soil engineering The results of mechanical analysis of the types of soils under investigation and their elative values of pF and moisture contents have been given in this paper which throw some light on texture of the soils, particularly in respect of the percentage of clay

EXPERIMENTAL

The pF/ Moisture content data at low suction pressures have been determined by the direct suction method. A thin sample of water saturated soil (of known dry weight) is placed in a Buchner funnel and subjected to a suction of known magnitude. Water leaves the soil until the soil suction rises to a alue equal to the applied suction Th moisture content of the

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TABLE 2

(*pF*/*Moisture Content data*)

(*A*) *Laterite Soil*

S.No.	R P M	h (cms)	pF (=logh)	Moisture content %
1	13000	91200·0	4·96	5·5
2	11000	30200·0	4·48	12·0
3	6500	12590·0	4·10	20·0
4	4500	5012·0	3·7	24·0
5	low pF	125·9	2·1	20·0
6		60·26	1·78	22·0

(*B*) *Delhi Sandy Loams*

S.No.	R.P.M.	h (cms)	pF (=logh)	Moisture content %
1	9500	21180·0	4·33	5·5
2	6500	12460·0	4·095	5·74
3	4500	4786·0	3·68	8·0
4	low pF	316·2	2·5	20·0
5		158·5	2·2	24·0
6		100·0	2·0	25·0

(*C*) *Bah Loams* (*Agra*)

S.No.	R P M	h (cms)	pF (=logh)	Moisture content %
1	6500	13420·0	4·13	10·9
2	4500	5093·0	3·707	14·0
3	2250	1274·0	3·105	18·0
4	low pF	501·2	2·7	20·0
5		398·1	2·6	21·5
6		158·5	2·2	26·0

(*Contd on the next page*)

TABLE 2 (*Contd.*)

(D) *Clay Loams* (*Delhi*)

S.No.	R P M	h (cms)	pF (=logh)	Moisture content %
1	9300	21180.0	4.33	8.5
2	4500	4729.0	3.675	12.0
3	3500	7852.0	3.455	14.0
4	low pF	339.0	2.601	38.0
5		316.2	2.5	45.0
6		126.0	2.1	53.0

(E) *Makhoob Yagar Soil*

S.No.	R.P M	h (cms)	pF (=logh)	Moisture content %
1	15000	91200.0	4.96	3.0
2	6000	18620.0	4.27	12.0
3	5000	7079.0	3.85	31.8
4	low pF	489.6	2.69	61.0
5		389.0	2.59	56.0
6		223.9	2.35	68.0
7		199.5	2.3	70.0
8		65.07	1.82	72.5

(F) *Black Cotton Soil*

S.No.	R P M	h (cms)	pF (=logh)	Moisture content %
1	14000	47670.0	4.678	19.0
2	6500	14360.0	4.157	33.5
3	4500	5451.0	3.7363	16.7
4	2250	1362.0	3.1315	41.7
5	low pF	926.8	2.9670	48.6
6		819.1	2.9133	50.7
7		646.6	2.8106	57.0
8		538.8	2.7314	52.0
9		431.0	2.634	60.0

DISCUSSION

In table I the clay silt and sand percentages of six different Indian soils have been given. It is to be noted that the clay percentage of Black Cotton soil is the highest (70 %) Then come Mahboob Nagar soil (63 %) clay loam (34 %) Delhi sandy loam (21 %) Bah loams Agra (20 6 %) and Laterite (8 %) The order with respect to clay percentage is as follows Black Cotton > Mahboob Nagar > Delhi clay loam > Sandy Loam Delhi > Bah Loam Agra > Laterite.

The Delhi sandy loam and Bah Loam (Agra) run close to each other in the percentage of clay The other important constituent is sand which has the following order

Laterite (83 %)	>	Delhi Sandy Loam (65 %)	>	Bah Loam (59 48 %)	(Agra)>	
Mahboob Nagar (25 %)	>	Delhi clay Loam (24 %)	>	Black Cotton (19 %)		

It is evident from the foregoing order of clay and sand percentages that the more clayey soils have lesser sand percentages and this in general should be expected. Any variation in this relation may be due to the variation in the percentage of silt which is observed in Delhi Clay Loam where the silt percentage is the highest (42 5 %)

The pF/moisture content data on these types of soils are very much convincing regarding the relation between the clay percentage and moisture retentive power It will be seen in the curves how the moisture content varies with the pF value The Black cotton soil leads the rest in its pF value corresponding to a certain value of moisture content. At low moisture content the pF of black cotton soil remains higher than the Mahboob Nagar soil but at moisture contents higher than 36% the pF value of Mahboob Nagar exceeds a little to that of the black cotton. This observation is interesting and seems to be due to the difference in the behaviour of the clay minerals with increasing moisture which may not be identical in the two types of soil The pF moisture content curve of clay loam follows a normal sequence according to the percentage of clay The behaviour of Delhi Sandy Loam and Bah Loam (Agra) also form the regular sequence according to the of clay The laterite soil which is the least clayey soil shows a beyond 26 moisture content. This unusual behaviour of may arise out of an abrupt constancy in the moisture holding clay or its minerals at higher moisture level which is very prol soils

All the foregoing observations appear useful indices rization of the types of soils and it is evidenced by the m content curves that the black otton, Mahboob Nagar Delhi Soils will retain moisture much more strongly than Loams The foregoing observations on pF and moistur

us to categorise Black Cotton Mahboob Nagar and Clay Loam Delhi, Bah loam, Delhi sandy loam and laterite soils with regard to their moisture holding strength which is of much importance for the stabilisation of soils in buildings and road construction.

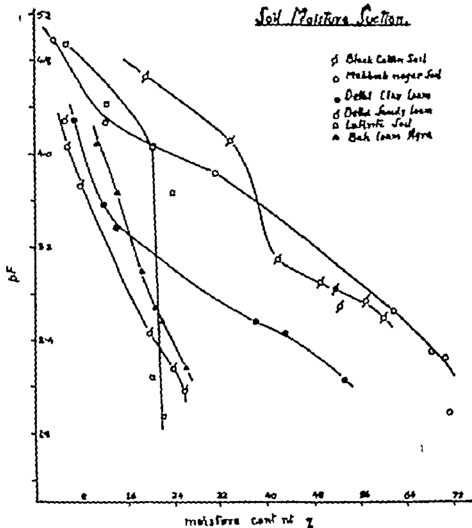
The vapour pressure and moisture content relation swelling and shrinkage of these soils will be communicated shortly Further work is in progress.

Summary

Study of soil suction and its moisture content is of vital importance to the road engineers. With this end in view six typical Indian soils have been investigated for their pF/ Moisture content data and the values have been discussed in relation to the clay silt and sand percentages in the soil.

Acknowledgement

Thanks are due to the C.S.I.R for the award of a grant and Research fellowships to two of us (D K. and P D B.)


Soil Moisture Suction.
Black Cotton Soil
Mahboob nagar Soil
Delhi Clay loam
Delhi Sandy loam
Laterite Soil
Bah loam Agra
5.2
4.8
4.0
3.2
2.4
1.6
pF
8
16
24
32
40
48
56
64
72
moisture content %

COMMENTS ON PAPER ON
"THE ORIGIN OF LIFE" By O N PERTI

SIDNEY W FOX
Florida State University Tallahassee

The paper in Agra University Journal of Research Vol. XII Pt. II May 1963 pp. 1-48 fails to take into account many facts. Some of these are explained hereunder

The argument that heat is an agent for the denaturation of proteins (p. 15) cannot justifiably be used against the origin of protein by thermal condensation of amino acids. Food technologists have shown in general and other scientists have shown in this particular context that the rate of denaturation of protein is extraordinarily sensitive to contents of water I have treated this point at some length in publications one is *Science 132* 200 (1960)

Perti also states "The value of thermal pathway can only be considered if it can be shown decisively or even in a general manner whether this thermal protein was incorporated into the first terrestrial organism" The same article in Science plus others published 1959-1963 show in fact how thermal protein could have organized itself into cellular forms, referred to as microspheres. The numerous attributes of these microspheres which indicate a kinship to cells are recorded since 1959 in the literature. Nowhere in Perti's article is mentioned any of these properties or microspheres themselves. This omission is difficult to understand in view of Perti's heavy emphasis on coacervate droplets and the latter-day units described by Perti partly from experiments conducted with Krishna Bahadur

In view of my own private communication from D H M Briggs the statements on p 16 are garbled. Dr Briggs eports weak esterase activity in proteinoids prepared by heat in the absence of water according to our procedure. We have also reported in publications the same (p. 47 in M Stahmann ed. Polyamino Acids Polypeptides, and Proteins, University of Wisconsin Press, 1962) kind of esterase activity as have Noguchi and Saito (same volume, p 313) This paper also treats the problem of heat denaturation.

The way in wh ch we compared ou cell-like un ts to formed elements in meteorites in a symposium in 1961 is presented incorrectly on p 27 The last half of the statement attributed to me is categorically untrue.

A fuller comparison to cells was presented by me in a symposium in 1962 and since published with Shuhei Yuyama in *Ann. N Y Acad. Sci. 108* 487 (1963) and also in the First Annual Report of the Institute for Space Bi o-sciences, Florida State University 1962.

Finally in order to present the outlines of the full true picture, I should point out that Dr Krishna Bahadur with whom Dr Perti on p. 22 claims collaboration worked as research associate in our laboratory from late November 1962 to early April, 1963 He left before his appointment had been fulfilled but after he became familiar with the behavior and potentialities of microspheres as described in our laboratory notebooks. In one of these notebooks was described, for example, increases in number of microspheres in experiments. These results, obtained on a Coulter electronic counter had not been rigorously repeatable as in Bahadur s later experiments, they did not in my view warrant publication and interpretation as biologically meaningful. Subsequent to his departure, Dr Bahadur submitted to me a paper yet in my files which made the claims of growth, multiplication and metabolic activity Neither our laboratory nor that of Dr Richard S Young at the Ames Research Center Mountain View California had been able to obtain in repetitions of his experiments the results Bahadur claimed. I accordingly required removal of my name from that paper

Had these results been duplicable, we would have disagreed with the inferences Dr Bahadur or more recently Dr Perti, drew from the experiments of this sort.

In recent years, experimentation with concepts of abiogenesis has gained respectability it formerly lacked. The appearance in this field of publications which are unfactual can harm the advance of this branch of science, and they deserve prompt correction.

UTILITY OF THE BARK OF NYCTANTHES-ARBOR TRISTIS (HARSINGHAR OR PARIJATTAKA) IN DYEING OF TEXTILE FIBRES—ESPECIALLY WOOL

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INTRODUCTION

Nativity Nyctanthes-Arbor Tristis known as Harsinghar Har Parijat taka, Singhar etc. is a shrub of about 5 to 8 feet high with rough leaves and sweet scented flowers. It occurs abundantly in sub-Himalayan and Terai Districts *e.g.*, Nepal Uttar Pradesh, Assam, Bengal and also in Central India, Burma and Ceylon It is commonly grown in gardens all over India.

Historical Background This plant is well known in India since ancient times and is referred in Bhagavata in a well known story according to which Lord Krishna got it planted in the gardens of one of his queens in such a manner that the majority of flowers fell in the neighbouring garden of another in order to please both of them. The flowers are used in Hindu worship and routine offerings. The flower is important for its mythological background as it is mentioned in Vishnu Puran as 'Parijatak'

Therapeutic Value of Plant The various parts of this plant have found their use in curing many diseases The leaves and their aqueous extract are used in fever rheumatism and Sciatica The expressed juice of the leaves is given to children as a remedy for intestinal worms and is also a laxative. The bark is used as a Cholagogue and laxative, in pan to promote expectoration and also as a remedy for snake-bite. The powdered seeds are used in treatment of scaly disease of the scalp

Dyeing Property of the Bark. The inner portion of the bark when mixed with lime gives a red colouring matter but it is not used in dyeing The aqueous extract of the bark has been found to impart light brown colour to scoured wool in acid medium, but the shade obtained was not found fast to washing and soaping

The hot water extract of dried flowers is used for dyeing cotton and silk, especially silk is dyed in yellow to orange shade The Murshidabad saries are dyed to yellow and orange shade in the water extract o fdried flowers though the shades are fugitive to external agents.

In the present work the scoured wool was treated with aqueous bark extract and then treated with solutions of various diazotised bases which gave fast shades ranging from yellow to violet red. For comparision, the wool was

treated with Tannic acid and also Tanninol BM (Synthetic Tannin agent) separately and then treated with the solution of diazotised bases. The shades obtained were resolved into primary colours by means of Lovibond Tintometer and the results tabulated.

EXPERIMENTAL

Extraction The bark taken out from Harsinghar or Parijatak tree was dried in sun The dried bark was powdered 50 gms. of powdered bark were extracted with 325 c. c. water in a Soxhlet Apparatus The resulting 240 c. c. of dye solution were used immediately to dye wool as it showed a tendency to become turbid on keeping

Dyeing 6 gms Skein of wool was thoroughly wetted by boiling with 0·5% Calsolene Oil Hs (material/liquor ratio 1 40) at 80°C for one hour The wetted material was thoroughly rinsed with water and immersed in 240 c. c. of aqueous extract of bark (material/liquor ratio 1 40) 4% Acetic Acid and 20% Glauber salt on the weight of material were added to the dyebath which was raised from 55°C to 75°C in 45 minutes At the end of this period 2 % Sulphuric Acid on the weight of material was added and the material boiled for further half an hour Then it was rinsed and dried.

Development The base (? gms.) was dissolved in Hydrochloric acid and diazotised as usual with sodium Nitrite In some cases the indirect method of diazotisation was used. The diazo solution so obtained was diluted to the required extent (for material/liquor ratio 1 40) after addition of Sodium Acetate neutralising mineral acid. The dyed woollen hank was immersed in it and dyed for 1 hour at room temperature Then it was rinsed and boiled with 2 % Neutral Soap solution for 1/2 hour and dried

Colour Measurement The colour of dyed hanks was measured with Lovibond Tintometer The Lovibond Tintometer is a substractive trichromatic colorimeter which expresses color of an object in terms of three primary colours (viz Red Yellow and Blue) Light reflected from a standard white surface namely Magnesium Carbonate is matched with the light reflected from sample by passing it through a combination of filters placed one behind the other The colour is defined by the number of series of red, yellow and blue filters used.

The dyed and developed hank of wool was wound on a white piece of card board and this was used to measure the colour In order to compensate any errors due to difference between whiteness of card board and standard white, a piece of white card board was wound with white wool and comparisons made against it instead of standard white The readings obtained are given in the table appended.

Similarly wool was treated with 1% Tannic Acid and 1 Tanninol BM and developed with bases. The Tintometer readings for these are also given in the table.

Conclusion

Generally for dyeing of cotton with all round fast colours Azoics (Naphthol, and Vat Colours are used where the use of caustic soda is made in dyeing The Fast Bases which have been used in these experiments can only be applied on the naphtholated material i e first the material is treated with the naphthol solution and then developed with the solutions of Fast Bases. As naphthols are applied from alkaline solution it is not possible to use naphthols on wool due to deleterious effect of alkali on wool hence the present work was undertaken to find the possibility of applying the Fast Bases to wool Thus the naturally occuring material was tried namely the extract of the Bark of Harsinghar (Nyctanthes-Arbor Tristis) and from the results it is evident that beautiful fast shades ranging from yellow to violet Red can be obtained As the application of Fast Bases require careful control of conditions like pH and temperature, in place of Fast Bases Fast Salts (which are stabilized diazosalts) can be used. These Fast Salts are soluble in water and are easy of application. Thus the extract of Harsinghar Bark can be easily made use of in Cottage Industries for dyeing wool in Fast colours with the help of Fast Bases or Salts.

3	4	5	6	7	8	9	10
7 8	7 9	0 9	Orange	8 6	7 2	2 3	Red Orange
6 2	9 7	0 5	Yellow Orange	7 2	7 2	2 1	Orange
10·6	3 6	3 0	Red	10·9	5 4	3 4	Orange Red
3 5	5 3	1 5	Orange Red	6 6	9 1	3 0	Y llow Orange
3 7	6 0		Yellow Orange	7 0	8 1	2 0	Y llow Orange
6 2	5 9	1 5	Red Orange	9 3	7 2	4 2	Red Orange
6 9	7 9	0 9	Orange	9 8	9 1	4 8	Orange

11	12	13	14	15	16	17	18
7 5	9 3	4 6	Yellow Orange	7 7	9 9	1 8	Yellow Orange
5 5	8 4	3 1	Orange Yellow	6 1	8 4	1 1	Yellow Orange
10 3	7 3	3 7	Red Orange	11 1	5 0	3 0	Orange Red
8 0	9 5	5 0	Yellow Orange	5 0	9 9	2 5	Orange Yellow
6 0	9 4	3 1	Orange Yellow	5 2	9 5	0 3	Orange Yellow
8 0	9 8	5 6	Yellow Orange	7 4	8 4	2 7	Yellow Orange
6 0	9 6	4 2	Orange Yellow	7 0	7 0	1 6	Orange

ABSTRACT OF THESES

RESPONSE OF CERTAIN NUTRIENT ELEMENTS IN CROP PLANTS IN RELATION TO pH AS REFLECTED BY GROWTH AND UPTAKE

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Botany Department D.A V College Kanpur India

Expression of traits, particularly of uptake, growth and yield is the result of the genetic and environmental interaction in plants. Therefore for the complete exploitation of the genotype in crop plants optimal conditions of nutrition are of immense significance. Amongst the nutritional conditions deficiencies of nitrogen and phosphorus are very common in the soils of Uttar Pradesh. Moreover pH which has a profound effect on the absorption of nutrient ions and consequently on the growth and yield of crop plants varies from place to place. This necessitates the evaluation of the nitrogen and phosphorus requirements at different pH levels in all crop plants.

In view of the above facts, work on the problem 'Response of certain nutrient elements in crop plants in relation to pH as reflected by growth and uptake' was started in pot culture house of the Government Agricultural College, Kanpur since July 1958. Although study was undertaken on wheat, paddy linseed and barley but afterwards the latter two crops were kept for detailed investigations. Amongst the nutrient elements, nitrogen and phosphorus were selected along with five pH levels viz. 5, 6 7 8 and 9 The studies were carried out in sand using Shive's solution as the basis Linseed crop was grown for two years and in the second year certain treatments of nitrogen and phosphorus were changed on the basis of the results obtained in the first year The second crop Barley was grown only for one year The concentration of nitrogen and phosphorus used are

Linseed Year 1959-60

Nitrogen		ppm according to adjustment	
	1/3 Normal Shive's solution	3 7	[illegible]
	Normal " "	11·0	[illegible]
	3 Normal " "	33·0	[illegible]
Phosphorus			
	1/3 Normal Shive's solution	11·0	[illegible]
	Normal "	33·0	[illegible]
	3 Normal "	99·0	[illegible]

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Five levels of pH viz. 5 6 7 8 and 9 were taken and thus in all 45 treatments were employed. For each treatment five replications were maintained

Linseed and Barley 1960-61

		ppm according to adjustment	
Nitrogen			
	Normal Shive s solution	11 0	N
	3 Normal ,,	33·0	3N
	9 Normal ,,	99·0	9N
Phosphorus			
	1/9 Normal Shive s solution	4·1	P/9
	1/3 Normal ,,	12 4	P/3
	Normal ,,	37 2	P

The same five pH levels as of 1959-60 were taken and for all the 45 treatments five replications were maintained.

Seeds of Linseed Type 1 and Barley K 12 were obtained from the Economic Botanist, U P Fresh supply of nutrient solutions was given at weekly intervals after washing of the pots. Observations were made for growth (Shoot height, Fresh and Dry weights of shoots and roots at short intervals Branching) flowering fertility yield and seed quality All results were analysed statistically by "Analysis of varience method."

RESULTS

The results presented in the Vol 2 of the thesis illuminate on the importance of various treatments in Linseed and Barley Individually of these treatments, in linseed hydrogen ion concentration appears to occupy a pivotal position around which the effectiveness of nitrogen and phosphorus revolves Next to pH nitrogen is important from two points of view In the first place the element itself is of paramount importance to the vegetative growth of the plant. Secondly the availability of phosphorus seems to be influenced by the amount of nitrogen in the nutrient solution supplied Support to th second view is also lent by Duncan and Ohlrogge (1959) and Das (1958) The importance of nitrogen as nutrition needs no emphasis and has been confirmed over and over again by a number of workers (Ranjan and Das 1957 Hoshino et. al. 1938 Tanaka et. al. 1959 Langer 1960 Raheja and Misra 1955 Lal and Rao 1960 and others)

In the present investigation the author himself got substantial proof of the importance of nitrogen as nutrition The height of shoot, fresh and dryweights of shoot and root number of flower buds flowers fruits, and seeds all had a stimulating effect of nitrogen in larger doses However the fertility of the plant decreased to great extent with the increase of nitrogen supply

Phosphorus requirement of linseed seems to be meager The higher concentration of phosphorus invariably resulted in poor growth and yield of plants The invigorating effect of phosphorus started at P/3 level and continued till P/9 the lowest concentration used in the present investigation. The treatment P/9 remained best individually as well as in the interaction 9 N × P/9 × pH 6 But as regards root growth individually the treatment P came out to be the best.

The hydrogen ion concentration seems to effect plant growth directly as well as indirectly The best level of hydrogen ion concentration both individually and in interaction was found to be pH 6. Any deviation from this pH on either direction had an unfavourable impact on plant growth. It has been argued by a number of physiologists and ecologists that the hydrogen ion concentration of the medium plays a very important role in the absorption of certain mineral nutrients (viz. Fe, Al P etc.) from the medium. In the present investigation the findings reveal that absorption and utilization of nitrogen is influenced by the hydrogen ion concentration to a great extent. Although the pH 6 remained best treatment individually and in combination for shoot height, shoot fresh and dry weights, number of flower buds, flowers fruits seeds yield and yield of oil but as regards the fertility of the plant higher pH levels were superior This might be due to the fact that higher pH levels plant gets only a meager supply of nitrogen from the nutrient solution even if it is present in plenty On turn lesser availability of nitrogen is favourable for the high fertility of the plant.

In the light of the cumilative effect of nitrogen, phosphorus and pH it is revealed that the best yield is obtained at the interaction 9N × P/9 × pH 6. However higher doses of nitrogen and phosphorus proved to be the most detrimental (9N × P/9 × pH6) 0·6482 g seeds per plant (9N × P/3 × pH 8 0·0174 g seeds per plant and 9N × P × pH 9 0·0276 g seeds per plant) Thus it is evident that the increase in the supply of nitrogen or phosphorus dose not necessarily lead to the increase of yield of linseed In fact the effect of nitrogen is conditioned to a great extent by pH and also by the amount of phosphorus. As regards the percentage of oil in the seeds the lowest concentration of nitrogen at neutral o alkaline pH proved to be the best, but the yi ld of oil remained maximum at 9N × P/9 × pH 6 interaction Besides it has been observed that the wideni g of the N/P ratio is useful both for vegetative and reproductive phases

It has also been concluded that the nitrogen requirements of linseed are different at different periods of its growth. More nitrogen is required during the vegetative phase while the same leads to high degree of l fertility in the reproductive phase. In view of th various findings, the following suggestions of practical value may be enumerated

1 In the early sown crops of linseed, heavy application of n trogen shall be beneficial as it will result in the formation of large number of

buds and in yielding a high percentage of their maturation into fruits before the leaf fall and the driage of the plants.

2. In the crops sown late the heavy application of nitrogen shall prove detrimental The bud formation in the present case shall continue even after the leaf fall and the driage of the plants. The maturation of a large number of these buds shall not be possible because of the limiting effect of carbohydrates the requisite amount of which will not be available because of the loss of the leaves. In order to obtain better yields in the late sown crops lesser amounts of nitrogen should be supplied. This is in keeping with the view that the lower levels of nitrogen have an stimulating effect on the reproductive phase and must, therefore result in the maturation of most of the buds into fruits

3. In the present investigation it has been observed that the widening of the N/P ratio is benificial to the vegetative as well as to the crop yield

4 Better yields of the crop may be obtained by supplying heavy doses of nitrogen if the reaction of the medium is slightly acidic (pH 6) while in the medinm with alkaline pH (pH 8 and 9) better yields may be obtained by supplying nitrogen in low concentration

Coming to th effect of nitrogen phosphorus and hydrogen ion concentration on barley it may be mentioned at the very outset on the basis of the present investigation that barley is alkaliphilus whereas linseed is mesophilous or acidiphilous. But it is interesting to note that inspite of this basic difference in the two crops the best interaction of N P and pH for both remains the same 9N × P/9 × pH 6.

As regards the ndividual treatment of nitrogen for barley 9N gives the best results for both the vegetative and the reproductive phases The protein content of the seeds as determined by the total nitrogen is also increased by supplying higher levels of nitrogen

The phosphorus requirement of barley as that of linseed seems to be meager P/3 being the best treatment individually In the interaction of nitrogen phosphorus and pH P/9 proves to be the best treatment as reg rds y elds. The availability of phosphorus to the plant is increased when the amount of nitrogen in the medium is sufficiently high.

The pH level for the best development of the vegetative and reproductive phases are very much different. Best results are obtained at pH 5 as regards th vegetati e growth however for the best reproductive growth alkaline pH is req ired. This s explained on the basis of the fact that at lower pH levels more n trogen is obs rved by the plant and consequently vegetative growth of the plant is timulated.

In view of the various findings following suggestions of practical utility may be stressed for barley

1 Heavy application of nitrogen irrespective of time of application will be beneficial.

2 Heavy application of nitrogen at all levels of pH will be useful.

3 The wider N/P ratio will prove beneficial in getting good yields at all pH levels

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STUDIES ON THE MORPHOLOGY AND FLORAL BIOLOGY OF SOME IMPORTANT LIMES AND LEMONS GROWN IN UTTAR PRADESH WITH SPECIAL REFERENCE TO THE BEARING BEHAVIOUR OF *KAGHZI LIME**

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INTRODUCTION

The present studies on the Morphology and floral biology of limes and lemons grown n Uttar Pradesh with particular reference to the bearing be haviour of Kaghzi lime have been undertaken at the Govt. Horticultural Research Institute Saharanpur during the years 1960-62.

Seventeen important limes, lemons and other citrus rootstock varieties of Uttar Pradesh, *i.* Sadaphal, Amilbed Dominica, Sour Orange, Rangpur lime, Jambheri, Jambheri Brown, Italian 76 Florida Rough, Karna Khatta, Sweet lime, Lemon Oval Kaghzi lime, Lemon Eureka, Lemon Kaghzi Lemon Seedless and Sour Galgal were selected for the investigations.

RESULTS

The investigations were carried out under different heads *viz.* classification, physico-chemical analysis, poly-embryonic studies, floral biology pollen studies, fruit-set studies, bearing behaviour of Kaghzi lime and incom patibility studies in Sweet lime, and the results are summarised as follows —

1 Classification An intermediate system of classification between that of Swingle and Tanaka has been proposed and a key for identification of these 17 varieties is also suggested. The present classification is mainly based on morphological characters and is partially supported by physico-chemical, polyembryonic and pollen studies. All the varieties studied, thus, have been placed under ten distinct species.

Placings of Amilbed as *C tris pennivesiculata*, Sweet lime as *C limettioides* Rangpur lime as *C limonia* Karna Khatta as *C karna* and Jambheri as *C jambhiri* as suggested by various other workers have been upheld.

Lemon Oval Lemon Kaghzi and Dominica varieties have been considered to be of hybrid origin and pla ed under *C limon*. Jambheri and Florida Rough on one hand and Jambheri Brown and Italian 76 on the other hand have been conside ed synonymous and are grouped under the varietal names of Jambheri and Jambheri B own espectively Amilbed trees grow

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ing at this Institute have been observed to be Gajanimma of South India and hence grouped as *C pennivesiculata* as suggested by Tanaka.

Citrus semperflorens of Lushington has been considered a separate specific name for Sadaphal while Sour Galgal has been placed under a new species of *Citrus galgal*

2 *Physico-chemical analysis* The maximum peel percentage has been observed in Karna Khatta, while Sour Galgal possessed the highest per centage of rag and seeds. Of all the varieties, the fruits of Lemon Seedless have been found to be most juicy The total soluble solids as determined by a hand refractometer have been recorded to vary between 6 5 and 8 5 per cent. It is the highest in Jambheri Brown fruits. The optimum acidity expressed as per cent of citric acid has been recorded in Kaghzi lime fru ts of rainy season bloom, whereas the lowest is in the Sweet lime f uits. The fruits of Sadaphal and Am lbed have been found to be devoid of ascorbic acid, while the Sweet lime, the richest

The Kaghzi lime fruits of rainy season setting have been found larger in size, possessing more peel, but lesser rag seeds and juice.

3 *Polyembryonic studies* The highest percentage of polyembryony has been recorded in Jambheri (100 %) while Domin ca, Lemon Oval Lemon Kaghz and Lemon Eureka have been observed to be monoembryonic. The highest average number of embryos per seed in tl e polyembryonic variet es has been observed in Jambheri (4 70) while the least in Rangpur lime (1 75) The range of embryos per seed in these varieteis has been found to be 1 to 11 Jambheri and Florida Rough ha e been the only varieties which possessed a range of 2 to 8 embryos per seed.

4 *Floral Biology* Most of the varieties sta t flowe ng by the first or second week of February and continue t ll the 1st or second week of April Sadaphal Lemon Kaghz Lemon Eureka, and Lemon Seedless have been observed to flower throughout the year wh le Sour orange and Lemon Oval flower at least twice a year under Saharanpur conditions. The trees of Amilbed have been observed to blossom in leafless condition the flowers appearing mostly on matu e sl oots. The remaining other varieties have been found to shed their leaves only partially before flowering The flower buds appear first on the matu e shoot on the periphery of the tree, towards the sunny side

The development of a floral bud has been div ded nto six dist nct stages, from ts emergence to full bloom stage The flower buds appearing ea ly n the season m ture n longer per od than those emerging later on. This s due to low temper tu es preva l ng n early part of the bloom. Simila l the bud emerging in the rainy eason have been observed to open in a lesser period th n those emerg g either n spring or December The

buds emerging in December however mature in maximum period due to low temperatures.

The optimum anthesis in most of the varieties has been observed between 9 a.m. and 12 noon. A shifting of optimum anthesis period towards early hours of the day with the rise in temperature has been observed.

The dehiscence of anthers has been observed to start within 5 minutes to 1 7 hours after the exposition of anthers. The time required for complete dehiscence varies from 1 17 to 4·25 hours due to the influence of atmospheric temperatures. In Amilbed, Sadaphal, Sour Galgal, Lemon Oval Lemon Eureka, Lemon Seedless and Lemon Kaghzi anther dehiscence often starts 3 to 4 hours before anthesis. However this condition prevails in advance stages of bloom or during rains, when the temperatures warm up and is more frequent in staminate flowers.

The highest percentage of staminate flowers has been observed in Sweet lime, and the least in Lemon Kaghzi Low temperatures appear to have a definite influence on the initiation of higher percentage of hermaphrodite flowers.

The receptivity of stigma as tested by pollen germination in situ has been observed f om 3 days before till 5 days after anthesis in Karna Khatta, Lemon Oval and Lemon Kaghzi, while in Sour orange it is receptive f om 2 days before to 5 days after anthesis Sweet lime stigma remains re eptive from 3 days before to 3 days after the opening of flowers. However visual observat ons show the receptivity from 3 days before till 6 days after anthesis in all these varieties. As tested by fru t-set stigma of Rangpur lime has been observed to be receptive for optimum period f om 3 days before till 5 days after anthesis amongst the 10 varieties studied. Lemon Oval does not set any fruit except when pollinated on the day of opening of flowers and has the least receptivity The microscopic examination of sect ons of ovar es of Sadaphal, Dominica and Rangpu lime reveal that the pollen tube reaches embryo sac two days after pollination whereas the pollen tube in Sweet lime reaches only 4 days after pollination.

5 Pollen Studies The Pollen grains of all the varieties except for Sadaphal are prolate spheroidal, while of Sadaphal are prolate spheroidal to oblate spheroidal. Pollen of Karna Khatta, Lemon Oval, and Dominica a e tetra aperturate, whereas the est are tetra as well as penta aperturate. In Sweet lime a few giant size tri and hexa-aperturate pollen grains have been observed. Similarly in Kaghzi lime hexa-aperturate giant size pollen grains have been found.

Pollen fertility range of 52 2 to 91·6 per cent has been ecorded in these varieties. The concentrations of sucrose or glucose for optimum pollen ger mination vary with the variety The highest pollen germination has been

observed in Sour Galgal (82 2%) while it is the least in Kaghzi lime (11 8 %) An increase in percentage of pollen germination has been recorded in Sweet lime and Amilbed by the addition of 2 4 D in the sucrose media.

The pollen of Lemon Oval has been observed to be viable for 20 days at room temperature under ordinary conditions The optimum longevity of 60 days has been observed in Sour orange and Karna Khatta pollen when stored at 32° F with 25 and 50 per cent relative humidity respectively

6 *Fruit set studies* The maximum fruit maturity period of 245 days has been recorded in Sour orange and the minimum (106 days) in Lemon Kaghzi of the rainy season setting A hundred per cent fruit-drop has been found in spring bloom setting of Sour orange, Lemon Eureka and Lemon Seedless. The minimum fruit-drop occurs in Sour orange of rainy season bloom setting

7 *Bearing Behaviour of Kaghzi Lime* Five distinct vegetative flushes, commencing on 31 1 29-3 ?7 5 27 7 and 3 10 have been recorded in Kaghzi lime trees during 1961 The main contribution to the vegetative built up is by the first flush. The new shoots have been classified as non-vigorous, normal and vigorous. The highest percentage of vigorous shoots appears in the May June flush, while the highest percentage of normal shoots is found in spring flush

The non-bearing Kaghzi lime trees have been induced to flower in spring as well as in rains by withholding water root-pruning and manuring combined together In these trees, the flowering also starts 10 days earlier than the untreated ones during the spring A decrease in the yields has been observed if the operations are not repeated in the following season. However the treated trees are comparatively more vigorous and healthy

Defoliation alone or in combination with ringing has been found to be equally effective during September when other operations are not practicable due to prolonged rains under Saharanpur conditions.

8 *Incompatibility studies in Sweet Lime* Fruit-set studies in Sweet lime by different modes of pollination have shown that there is no self incompatibility in Sweet lime as reproted by some workers. The cause of low fruit-set has been attributed to high percentage of staminate flowers.

Amongst the various cultural treatments given for inducing a higher percentage of fruit-set and hermaphrodite flowers the highest percentage of hermaphrodite flowers has been observed in the case of ringing alone and combined with bending but the latter treatment recorded the highest fruit-set (1 39) Sprays of 100 ?00 and ?00 ppm IBA have given the significantly higher percentage of hermaphrodite flowers, whereas the highest percentage of fruit set was recorded with 100 ppm IBA sprays (2 80%)

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STUDIES ON THE GROWTH RATE AND AGE OF MATURITY OF THARPARKAR SAHIWAL AND RED SINDHI CALVES*

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Importance of the studies on the growth and protein requirement for growth have deen described with special reference to India

The references concerning general growth and protein requirement for growth have been deta led The work done in India has also been incor porated. The objective of the studies : On the growth rate of calves of Indian breeds of cattle on standard farm ration and to find out the protein requirement for optimum growth have been described.

The location of National Dairy Research Institute with special reference to Latitude and Longitude has been described. The management and feeding practices followed at N D.R.I., Karnal have been given.

The growth of Tharparkar Sahiwal and Red Sindhi breeds main tained at National Dairy Research Institute, Karnal has been studied. In addition to these, protein requirement for growing calves and effect of feeding three levels of protein on the growth and age of maturity has also been studied.

The data studied for growth consisted of observations on weight, heart-girth, from birth to six months at f rtnight interval, then from 7th month to two years of age at o e month interval. In female calves, the growth has been studied up to 4 years of age.

The growth records mostly comprise from October 1959 to January 1962 However the records for age at first calving have been taken from 1935 to 1961

The data has been grouped according to breed, age group, sex and season of birth The different methods of statistical analysis, as described by Snedecor (1956) have been f llowed.

The average birth weight for male calves were 21 74 $\pm$ 1.92 kg 21 70 $\pm$ 1.81 and 21 14 $\pm$ 2 16 kg for Tharparkar Sahiwal and Red Sindhi breeds respectively At b rth, the Tharparka and Sahiwal were significant ly heavier than Red Sindhi calves. For female calves the bi th weights were 21 04 $\pm$?.2 20 84 $\pm$ 2 13 and ?0 07 $\pm$ 2 19 kg respectively Tharparkar

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calves were significantly heavier than Red Sindhi female calves at birth In all the breeds females were lighter in weight in comparison to the male calves.

The coefficient of regression for growth for individual animal has been calculated. The byx values for male calves from birth to six months were 0.81 ± 1 14 6 33 ± 1 48 and 6 43 ± 1 48 kg per fortnight in Tharparkar Sahiwal and Red Sindhi breeds respectively In female calves the corresponding values were 5.98 ± 1.52 6 09 ± 1.35 and 5 17 ± 1.20 kg From birth to six months of age the male and female calves of Sahiwal breed grew at the same rate. In other two breeds the males gained at significantly higher rate than female calves.

It was of interest to note that from birth to 2½ months of age the rate of the growth was 340 6 gm per day in Tharparkar 309.3 gm. per day in Sahiwal and 340 0 gm. per day in Red Sindhi male calves. However in female calves the values were 290.0, 293 3 and 280 0 gm. per day for three breeds respectively The growth rate increased to 504 7 gm per day in Tharparkar 476.2 gm per day in Sahiwal and 466 0 gm per day in Red Sindhi male calves and 454.2 gm per day 407 8 gm per day and 394.0 gm per day in female calves respectively from 2½ months to 6 months of age.

The season of birth has got significant effect on the growth of calves. The calves born from November to February gained at significantly higher rate followed by other two seasons.

Similar trend as seen in increase in weight with age was observed in heart-g rth measurements with all the three breeds. The coefficient regression of growth per fortnight being 1 39 ± 1 45 1.33 ± 1 74 and 1.31 ± 1.61 inches for male calves and 1 31 ± 2.02, 1.38 ± 1 74 and 1 10 ± 1 93 inches for female calves of Tharparkar Sahiwal and Red Sindhi breeds, during the age from birth to six months. The effects of season and sex on heart-girth increase were found to be similar as weight growth The heart-girth measurements at birth were 25.07 ± 1 07 24 61 ± 1 07 and 24 88 ± 1.27 inches in the male cal es of Tharparkar Sahiwal and Red Sindhi breeds. In female calves the corresponding measurements were 24 88 ± 1 06 24 39 ± 0.91 and 24 07 ± 0 7 inches respectively

Positive correlation was observed in heart-girth measurement and the weight f om b rth to six months of age The r values were significant at t test and they varied from +0.61 to 0.89 showing that as the body weight increases the heart-girth measurement lso ncreases.

A great reduct on in growth rate was observed from 7th month to 12 months of age The growth was reduced almost to half th t of the growth from bi th to 6 month The a erage coefficients of egression of Tharparkar Sahiwal and Red S ndhi male alves were 6 41 ± 3.03 8 07 ± 3.01 and 7 01 ± 2.95 kg respecti ely For femal lves the same values were

7.11 ± 2.71, 8.42 ± 2.53 and 6.91 ± 2.71 kg per month in the three respective breeds.

An increased rate of growth was observed, however from one year to two years of age. The average weights at 2 years of age in male calves were 272.76 ± 32.46 kg., 276.36 ± 27.73 kg and 257.93 ± 35.72 kg and in females the weights were 246.25 ± 30.90 kg., 248.65 ± 35.18 kg and 227.27 ± 30.93 kg in Tharparkar Sahiwal and Red Sindhi breeds of cattle. The average coefficients of regression of growth from one year to two years being 11.48 ± 2.1, 11.49 ± 2.09 and 10.45 ± 2.73 kg in males and 9.40 ± 2.43, 9.52 ± 2.63 and 8.69 ± 2.58 kg respectively for Tharparkar Sahiwal and Red Sindhi female calves. Variation in growth rate due to sex was found to be significant. The male calves grew at higher rate in all the three breeds. Season of birth and breed also played a significant role. The winter born (Nov. Feb.) calves grew significantly better than the calves born in other two seasons namely summer (March-June) and rains (July to October). Sahiwal and Tharparkar calves gained at the same rate and at significantly higher rate than Red Sindhi calves.

The weight at conception of heifers were found to be 293.21 ± 40.6, 288.74 ± 31.07 and 262.58 ± 26.85 kg respectively for Tharparkar Sahiwal and Red Sindhi breeds. The corresponding weights at first calving were 376.37 ± 38.77, 380.16 ± 31.00 and 347.83 ± 41.13 kg respectively. The age at first calving in three breeds of cattle maintained at National Dairy Research Institute, Karnal was as follows

Tharparkar 42.68 ± 6.2 months.
Sahiwal 41.29 ± 5.4 months.
Red Sindhi 41.55 ± 6.2 months.

By age classification, it was observed that most of the heifers calved between the period of 3 years to 4 years of age.

With the view to obtain reliable data on the protein requirements of growing Indian cattle calves, long range systematic feeding trial was undertaken. This study was mostly confined to one of the most important milch breed of the country namely *Sahiwal*.

The feeding trial was conducted taking 36 calves (18 male and 18 female) of 6-12 months of age. The calves were divided into three different groups of 12 calves each. Out of these three groups one group was kept on a protein level according to the 20 above Morrison's feeding standard while the animals of one of the other two groups were kept at a D.C.P. intake of Morrison standard and the third group at 20 below the Morrison scale. The T.D.N. intake calculated on the basis of body-weight, was kept at Morrison standards for all the groups.

To achieve the above plane of nutrition in three groups the first group of animals were fed with concentrate mixture consisting of 40% Barley

50% Groundnut cake and 10% Wheat bran supplying theoretically 0.25 kg D.C.P and 0.72 kg of T.D.N per kg of this mixture, wheat straw was fed *ad lib* The animals of second group were fed a ration consisting of 50% Barley 40% Groundnut cake and 10% Wheat bran supplying theoretically 0.21 kg D.C.P and 0.72 kg T.D.N per kg of mixture. The calves of third group were fed a ration consisting of 50% Barley 30% of Groundnut cake and 20% Wheat bran, supplying theoretically 0.17 kg D.C.P and 0.72 kg T.D.N per kg of concentrate mixture. In addition to this the *calves of all the groups were given 5 kg of green feed or silage per day along* with 30 gm. salt and 15 gm of mineral mixture. Depending on the Nutritive value of the green feed or silage fed, the amount of concentrate mixture fed was reduced, so that the theoretically calculated amounts of D.C.P were supplied to individual calves according to their body weight and scale fixed for each group.

The average coefficients of regression of growth calculated per fortnight were 6.019 5.716 and 6.139 kg in the male calves in three groups namely 20% above Morrison scale, Morrison scale and 20% below the Morrison scale of feeding while in the females, the values were 5.386 4.782 and 4.855 kg respectively These differences were all found to be nonsignificant statistically Similar trend was observed in heart-girth height and length of the calves. The effect of feeding three levels of protein was found to be nonsignificant for these measurements.

The technique of collecting feeds, faeces and urine along with a *brief description of the stalls used for metabolism trials has been given* The chemical determination of various nutrients of food in biological materials has also been given.

Metabolism trials were conducted taking 9 male calves each time. Out of these 3 calves belonged to Morrison scale group, 3 to 20% above and 3 to 20% below this scale. All the calves showed positive balance as regards nitrogen calcium and phosphorus. In first trial the nitrogen balances were found to be +13.6[illegible] +11.08 and +8.40 gm in the three groups respectively The corresponding balances for second trial were found to be +22.08 +19.40 and +12.15 gm. respectively The theoretically calculated values of D.C.P and T.D.N intakes by conventional method did not fully agree with the actual availability of the ingredients and were always less than the calculated values. In the first trial the calves were theoretically fed with 463 416 444 383 331 3[illegible]7 [illegible]98 [illegible]94 and 290 gm of D.C.P But the actual availability was 406 391 338 339 203 31[illegible] [illegible]7 [illegible]7 and [illegible]97 gm of D.C.P respectively for the same calves Similarly during second metabolism trial the calves were fed theoretically with 543 543 483 41[illegible] 400 33[illegible] 318 30[illegible] and 303 gm of D.C.P But the actually available values were 477 [illegible]21 [illegible] 383 347 [illegible]86 [illegible]94 274 and 2[illegible]9 gm of D.C.P for the same calves.

On an average the dry matter consumption per 100 kg of body weight was found to be 2 112 kg in first trial and 2 066 kg in second trial. Although the wheat straw was fed *ad lib* but the dry matter consumption was limited to the above values. It can be assumed that the Indian growing cattle requires about 2 1 kg of D M per 100 kg of body weight for normal growth.

The digestibility coefficients have been calculated for different nutrients of the ration. The digestibility of the ration did not differ in different groups in the metabolism trial. But taking the two metabolism trial results separately in first trial when the concentrate mixture was supplemented with oats silage and wheat straw the digestibility of the ration was 60.52 ± 4 46 % whereas, in the second trial where berseem was fed in place of oats silage the digestibility coefficient became 65.39 ± 4 49 showing the associative effect of leguminous feed in increase of digestibility

The plane of nutrition of the calves have been discussed and have been compared with that of Morrison National Research Council and Sen's recommendations for growing animals.

The effect of feeding three levels of protein on the growth was studied. Amongst all the measurements of the growth namely weight heart girth length and height the growth in weight came out to be maximum, followed by heart-girth length and the height came in the last. The formulae of foreign and Indian workers were applied to know the body weight of the growing calves by heart-girth measurements. But none of the formulae could be applied correctly for these experimental calves.

The effect of feeding three levels of protein was also studied on haemoglobin content of blood. Slight effect of feeding different levels of nitrogen was found on the blood haemoglobin. However the seasonal effect on the haemoglobin ontent of blood was clearly seen. In younger calves higher values for l aemoglobin were found, whereas the percentage decreased as the age of the calves went up.

The effect of feeding tl ree levels of protein and the age of maturity of experimental calves was also studied. The following were the averages for age at first calving of the heifers in experimental animals.

20* bove Morrison scale group =33 60 ± 2 72 months.
Mor ison scale group =32.00 ± 3.53 months.
20 below the Morrison scale group =34 00 ± 2.75 months.

Th figures were about 8 months less than the average for the general l e l The importance of lowering the age at first calving with better feeding l gn t has been discussed.

I l u it emphasize that good growt nd a ly maturity can be t t l i sider bly less protein than that recommended in the Morris wa el g t ul

Part II

Progress in the development of the rumen festula technique has stimulated interest in the possible application of this technique in the evaluation of forage quality Such studies on the rumen Metabolism has been conducted by the author in cattle and buffalo. The studies have been carried out on the production of volatile fatty acids (VFA) and cellulose digestion. An attempt has been made to standardize the conditions of *IN VITO* experiments, with the view of attaining the reproduceable results comparable with those obtained in digestion trials.

The fitting of fistula, as well as the method for the estimation of cellulose and VFA has been described.

While comparing the production of volatile fatty acids and cellulose digestion in the rumen of cow calf and the buffalo calf it was found that only two VFA were found *i.e.* acetic and propionic. Production of acetic acid varied from 66 40 to 83 44 % whereas propionic acid from 16.56 to 35 46 %. Concentration of VFA was higher two hours after feeding than after 20 hours.

Buffalo calf produced much higher amount of VFA than cow calf.

The rate of digestion of cellulose in the first 24 hours was much greater in the buffalo though after 72 hours, the amount of cellulose fermented in the two species, was more or less the same. Coarse fodders, like jowar and *wheat straw* were least digested but when the wheat straw was mixed with berseem (a legume) the digestion went up from 30 74 to 58 68% in the buffalo and from 24.29 to 46.54 % in the cow calf

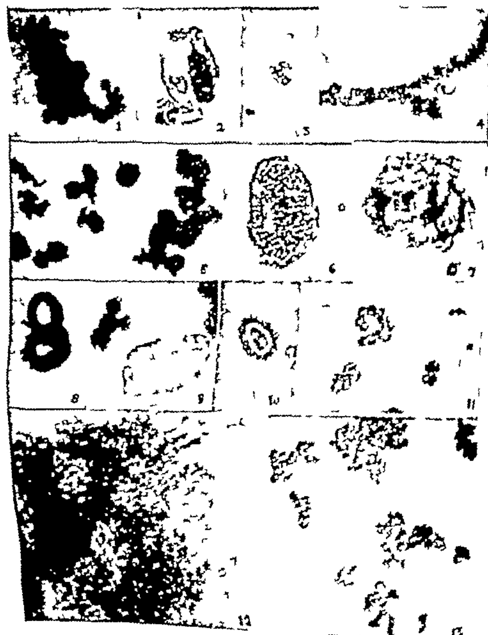
The relation between the production of acetic acid and the content of milk fat in the two species has also been discussed.

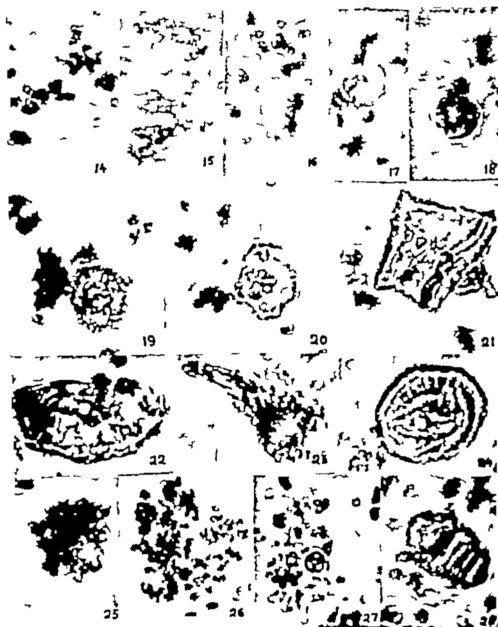
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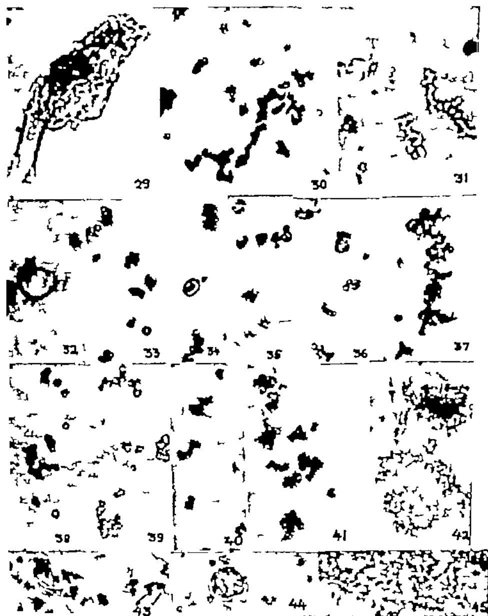
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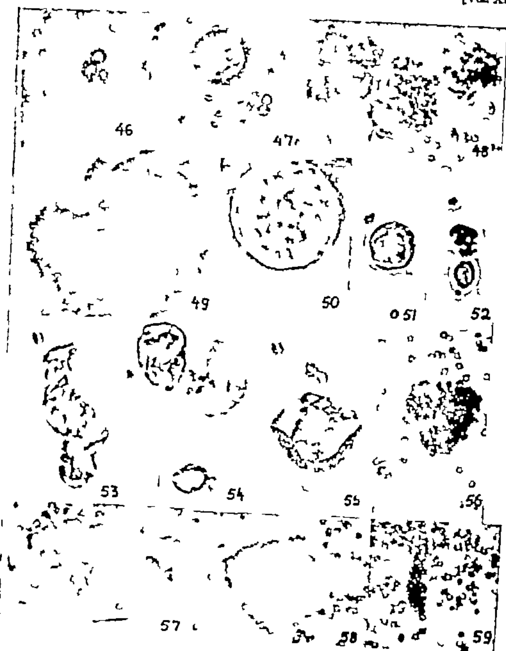
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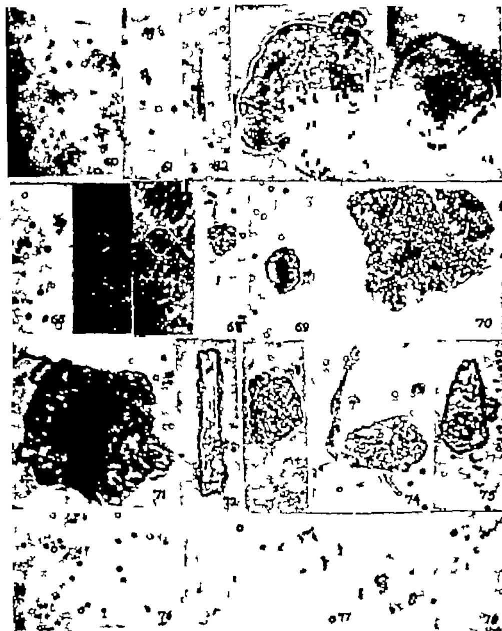
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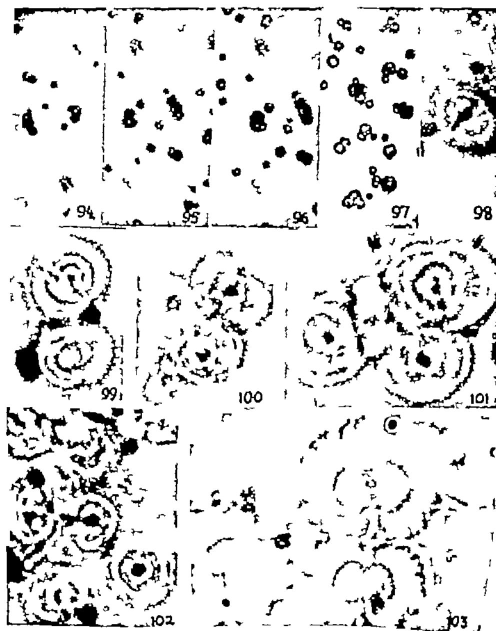

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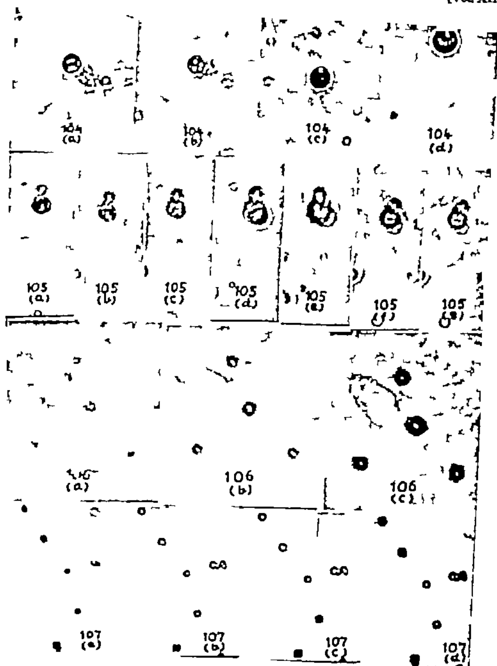

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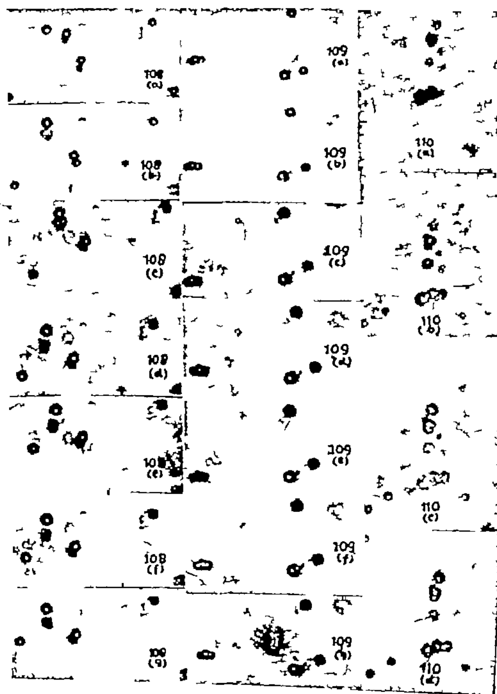

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A NOTE ON STEADY MHD FLOW IN AN ANNULAR CHANNEL

M. Ray
Principal, Agra College Agra.
AND
J C. Agrawal
Indian Institute of Technology Bombay

Introduction

The steady hydromagnetic flow of an incompressible fluid in an annular channel bounded by two infinitely long coaxial cylinders whose walls are porous and are capable of injecting or sucking in the fluid has been studied by Agrawal[1] when a constant pressure gradient exists in the direction of axis. In the present work is studied the radial and axial pressure variations in the same problem. The present study has revealed that the radial pressure variation unlike that in the absence of magnetic field[2] depends on the direction of the cross flow

Governing Equations and Symbols

For simplicity we have used the same symbols as in reference 1 Governing equations, their simplification and transformation to suit the conditions of the problem and geometry of the flow are again same as in reference 1 So we do not reproduce them here to avoid increase in the length of the paper However we have appended here the list of symbols used and their meanings. We will start with the equations (20) (21) and (23) which govern the flow in the present problem Equations (20) and (21) are coupled for the velocity and magnetic field and we are not discussing those here. The object of this paper is to discuss the pressure variation in the radial and axial directions, so we will start with the equation (23) of reference 1

Symbols used and Their Meaning

$p(r\ z)$ — Pressure at any point $(r\ \theta\ z)$ in the flow region
$(a \leq r \leq b\quad -\infty < z < +\infty)$

O_z — Axis of z taken along the axis of the annulus.

(O O O) — Origin chosen arbitrarily on the axis of the annulus and a right handed system of cylindrical polar coordinates has been assumed.

f — Total flux of suction or injection over a unit length along the axis at the surface of either cylinder or any imaginary cylinder in the flow region with Oz as axis $= aV_a = bV_b = rV_r$

a — Radius of the inner cylinder

b = Radius of the outer cylinder

V = Velocity away from the axis at the inner cylinder due to suction or injection at its wall.

V_b = Velocity away from the axis at the outer cylinder due to suction or injection at its wall

V = The component of the velocity along radial direction at any point (r θ z) It may be noted that in reference 1 this has been proved to be a function or r only $\left(=\frac{f}{r}\right)$ and the expressions for this in that paper are given by equations 37 and 39

H = Component of the vector $\vec{H}$ along z direction at any point in the flow region and expression for this are given in reference 1 by equations 38 and 40 This also has been proved to be a function of r only

ρ = Density of the fluid

μ = Permeability of the fluid

σ = Electrical conductivity of the fluid

λ = Magnetic diffusivity $= \frac{1}{4\pi\mu\sigma}$

NON DIMENSIONAL VARIABLES AND PARAMETERS

$$V = V\sqrt{\frac{\rho}{Pb}}$$

$$H = \frac{H\,b}{\alpha}$$

$$\xi = \frac{r}{b}$$

$$\pi = \frac{p}{Pb}$$

$$m = \frac{a}{b} \qquad (O<m<1)$$

R = Reynolds number (axial) $= \frac{b}{\nu}\sqrt{\frac{Pb}{\rho}}$ where ν is the kinematic viscosity of the fluid.

R_c = Reynolds number for cross flow $= \frac{b}{f}\sqrt{\frac{Pb}{\rho}}$

S^2 = (Magnetic pressure number)$^2 = \frac{\mu\alpha^2}{4\pi\ Pb^2}$

R_m = Magnetic Reynolds number $= \frac{b}{\lambda}\sqrt{\frac{Pb}{\rho}}$

VARIATION OF PRESSURE

The equation which gives pressure variation in the flow region of this problem is (equation 23 of reference 1)

$$p\ (r\ z) + Pz + \frac{Pf^2}{2r^2} + \frac{\mu}{8\pi}H^2 = \text{Constant} \qquad (1)$$

Therefore,

$$p(b\ z)+Pz+\tfrac{1}{2}\rho V_b = \text{Constant} \qquad (1a)$$

for $f=b\ V_b$ and $(H_z)_{=b}=O$ from the boundary condition 24 of reference 1

Subtracting (1) from (1a)

$$p(b\ z)-p(r\ z)=\tfrac{1}{2}\rho V_b^2\left(\frac{1}{\xi^2}-1\right)+\frac{\mu}{8\pi}H^2$$

Which gives

$$\frac{p(b\ z)-p(r\ z)}{\tfrac{1}{2}\rho V_b^2}=\left(\frac{1}{\xi^2}-1\right)+\frac{\mu}{4\pi\rho}\frac{H^2}{V_b^2} \qquad (2)$$

Also $p(\ \ z)=\frac{\rho f^2}{2r^2}+\frac{\mu}{8\pi}H^2=\text{Const} \qquad (1b)$

and substracting (1) from (1b) we get

$p(r,z)-p(\ ,z)=P$

giving—

$$\frac{p(\ z)-p(r\ z)}{z}=P=\text{Constant} \qquad (3)$$

The value of H is given by equations (38) and (40) of reference (1)

It is readily seen that f $\sigma\to 0$ *i.e.* the fluid becomes non-conducting $H\to 0$ (limiting case 2 of reference 1) This is because there is no interac tion in the field and flow there being no induced currents in the fluid due to its electrical conductivity being zero Equation (2) above in this case gives us the same result as equation (17) of reference 2 which shows that the pressure variation in the radial direction (when the magnetic field is absent or the fluid is non-conducting) although depends on the mag itude of the cross flow but is independent of the direction of the cross flow But in the present case, that is in the presence of radially applied magnetic field (and $\sigma\neq 0$) the presence va iation in the radial direction as is obvious from equation (2) above, depends on H also which in turn depends on the sign of R_e or sign of V V_b or V *i.e.* the direction of crossflow It may be noted that positive value of crossflow corresponds to fluid being feeded in at the inner cylinder and removed at the outer along the direction of r increasing Thus the p essure variation in the radial direction depends both on the magn tude and direction of crossflow It is eadily seen that the pressure increases in proceeding f om the inner cylinder to the outer annulus wall whatever be the direction of c ossflow It can be noted from equation (3) that pressure always dec eases in the direction of axial flow

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b = Radius of the outer cylinder

V = Velocity away from the axis at the inner cylinder due to suction or injection at its wall.

V_b = Velocity away from the axis at the outer cylinder due to suction or injection at its wall

V = The component of the velocity along radial direction at any point (r, θ, z). It may be noted that in reference 1 this has been proved to be a function or r only $\left(=\frac{f}{r}\right)$ and the expressions for this in that paper are given by equations 37 and 39

H = Component of the vector $\vec{H}$ along z direction at any point in the flow region and expression for this are given in reference 1 by equations 38 and 40. This also has been proved to be a function of r only

ρ = Density of the fluid

μ = Permeability of the fluid

σ = Electrical conductivity of the fluid

λ = Magnetic diffusivity $= \frac{1}{4\pi\mu\sigma}$

NON DIMENSIONAL VARIABLES AND PARAMETERS

$$V = V_z \sqrt{\frac{\rho}{Pb}}$$

$$H = \frac{H\,b}{\omega}$$

$$\xi = \frac{r}{b}$$

$$\pi = \frac{p}{Pb}$$

$$m = \frac{a}{b} \qquad (0<m<1)$$

R = Reynolds number (axial) $= \frac{b}{\nu}\sqrt{\frac{Pb}{\rho}}$ where ν is the kinematic viscosity of the fluid.

R = Reynolds number for cross flow $= \frac{b}{f}\sqrt{\frac{Pb}{\rho}}$

S^2 = (Magnetic pressure number)$^2 = \frac{\mu\omega^2}{4\pi\,Pb^2}$

R_m = Magnetic Reynolds number $= \frac{b}{\lambda}\sqrt{\frac{Pb}{\rho}}$

VARIATION OF PRESSURE

The equation which gives pressure variation in the flow region of this problem is (equation 23 of reference 1)

$$p\ (r, z) + P + \frac{Pf^2}{2r^2} + \frac{\mu}{8\pi}H^2 = \text{Constant} \qquad (1)$$

FIXATION OF NITROGEN BY TARTARIC ACID UNDER THE INFLUENCE OF ULTRAVIOLET LIGHT

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SUMMARY

Action of ultraviolet light on tartaric acid has been studied. It was found that in aqueous medium along with photodecomposition of tartaric acid fixation of nitrogen of the air in the form of amino acid also takes place.

INTRODUCTION

The action of ultraviolet light on tartaric acid was studied earlier by Euler and Ryd[1] who found that the acid decomposes giving rise to several reducing substances and carbondioxide. Later Volmar[2] found the presence of formaldehyde, formic acid glyoxal and reducing sugars among the decomposition products.

Photochemical production of amino acids by ordinary visible light using paraformaldehyde has been observed by Bahadur[3] and, Bahadur and Ranganayiki[4] The formation of amino acids by ultraviolet light using ammonium salt[5] and hydroxyl amine[6] has also been reported. It has also been noticed[7, 8, 9, 10, 11] that with carbohydrates as source of energy material photochemical formation of peptide bond takes place in aqueous solutions of amino acids. As pointed out earlier when tartaric acid is exposed to ultra violet radiations formaldehyde as well as reducing sugars are formed. In the photodecomposition a lot of energy change is also involved. It was therefore decided to reinvestigate the photochemical decomposition of tartaric acid under the influence to ultraviolet light with a view to see that if any fixation of nitrogen in the form of amino acid takes place. The results obtained are described in the paper

EXPERIMENTAL

A 5% solution of chromatographically pure tartaric acid in redistilled water was exposed to ultraviolet radiations at a distance of 37 cms from a 500 watt Elvak Universol Lamp. The exposure was carried out upto thirty minutes and every five minutes a portion of the solution was taken out and test for formaldehyde formic acid glyoxal and sugars was made. The results are given in table 1

Next 1% aqueous solution of tartaric acid with or without glycine alanine or glutamic acid was exposed to ultraviolet light. In order to have

comparative results simultaneously solutions of pure amino acids having a concentration similar to that used with tartaric acid was also exposed to the same source of ultraviolet radiations The results obtained are described in tables 2 to 4

The analysis of solutions was carried out chromatographically using the technique employed by Perti, Bahadur and Pathak[8-11] Circular and descending paper chromatographic technique was employed using butanol : acetic acid water (4 : 1 5) as solvent and ninhydrin (0 1 g/100 ml acetone) as developer

TABLE 1

Exposure of tartaric acid solution to ultraviolet light

Concentration of tartaric acid 5 g/100 ml

Exposure time in minutes	Tested presence of the following			Reducing sugar
	Formaldehyde	Formic acid	Glyoxal	
5	negative	negative	negative	negative
10	positive	negative	negative	negative
15	positive	negative	negative	negative
20	positive	negative	positive	negative
25	positive	positive	positive	negative
30	positive	positive	positive	positive

TABLE 2

Exposure of tartaric acid solution with or without glycine

Concentration of tartaric acid 1·0 g/100 ml

Concentration of glycine 0·1 g/100 ml

Exposure time in hours	Chromatographic Analysis (for amino acids)		
	Tartaric acid	Glycine	Tartaric acid and glycine
1	Glycine and alanine	Glycine and alanine.	Glycine and alanine.
4	Glycine alanine amino-n-butyric acid, valin + some unidentified spots.	Glycine, alanine and diglycine + some unidentified spots.	Glycine alanine diglycine amino-n butyric acid, valine + some unidentified spots.

TABLE 3

Exposure of tartaric acid solution with or without alanine

Concentration of tartaric acid 1·0 g/100 ml
Concentration of alanine 0·1 g/100 ml

Exposure time in hours	Chromatographic Analysis (for amino acids)		
	Tartaric acid	Alanine	Tartaric acid and Alanine
1	Glycine and alanine.	Alanine glycine + one unidentified spot.	Alanine and glycine.
4	Glycine alanine amino-n-butyric acid, valine + some unidentified spots.	Alanine, glycine, glycyl-glycine amino-n-butyric acid.	Alanine glycine, glycyl-glycine, amino-n-butyric acid, valine + one unidentified spot.

TABLE 4

Exposure of tartaric acid solution with or without glutamic acid

Concentration of tartaric acid 1·0 g/100 ml
Concentration of glutamic acid 0·1 g/100 ml

Exposure time in hours	Chromatographic Analysis (for amino acids)		
	Tartaric acid	Glutamic acid	Tartaric acid + glutamic acid
1	Glycine and alanine.	Glutamic acid and amino-n-butyric acid.	Glutamic acid.
4	Glycine, alanine amino-n-butyric acid, valine + some unidentified spots.	glutamic acid.	Glutamic acid amino-n-butyric acid, valine + unidentified faint spots

DISCUSSION

When a 5% aqueous solution of tartaric acid was exposed to ultra violet radiations from a 500 watt Elvak 'Universol' Lamp formation of formaldehyde could be detected after 10 minutes of exposure. After 20 minutes of exposure glyoxal could also be identified in the solution. When exposure was increased further by 5 minutes the formation of formic

acid was also noticed. Increase in exposure time upto 30 minutes indicated the formation of reducing sugars in addition to formaldehyde, glyoxal and formic acid. These results are in conformity with those reported earlier by others.[1, 2] They however indicate that in all probability formaldehyde is first formed which begins immediately to polymerise into glyoxal and finally to reducing sugars. At the same time part of the formaldehyde produced is also oxidised to formic acid (Table 1)

On exposure of a 1% solution of tartaric acid to ultraviolet radiations for 1 hour presence of glycine and alanine in the solution could be detected. When exposure time was increased upto 4 hours besides glycine and alanine presence of amino-n-butyric acid and valine was also observed along with small amounts of certain unidentified compounds. This indicates that fixation of nitrogen takes place in the form of amino acids during the decomposition of tartaric acid by ultraviolet light (Table 2)

Glycine alone when exposed to ultraviolet light for 1 hour shows the formation of alanine, and increase of exposure time upto 4 hours shows the formation of glycyl-glycine and other unidentified compounds in very small amounts. Similar results were obtained by Pertl and Pathak[3] and, Perti, Bahadur and Pathak[4] when they exposed a solution of glycine to sunlight or light from a 1000 watt bulb The present results show that ultraviolet light is more effective in bringing about such a change in a short time.

When a mixture of tartaric acid and glycine was used no new compounds could be detected except those which were seen to be formed when tartaric acid and glycine were exposed to ultra violet radiations separately

Similar results were obtained when alanine was used in place of glycine (Table 3) This is in conformity with the earlier observations of production of glycine from alanine and vice-versa under the influence of sunlight or artificial light from a 1000 watt bulb[3, 4]

Substitution of glutamic acid in place of glycine or alanine followed more or less a similar course of reaction (Table 4) It was noticed that when glutamic acid alone was exposed to ultraviolet radiations for 1 hour amino-n-butyric acid was formed which however appeared to decompose when exposure time was increased to four hours. When a mixture of tartaric acid and glutamic acid was used amino-n butyric acid was detectable even after 4 hours exposure time. This was presumably because tartaric acid alone when exposed to ultraviolet light can give rise to amino-n-butyric acid.

Conclusion

When aqueous solution of tartaric acid is exposed to ultraviolet radiations from a 500 watt Elvak Universol Lamp then in the beginning photodecomposition of tartaric acid takes place and upto 30 minutes exposure time formation of formaldehyde glyoxal formic acid and reducing sugars is noticed.

On increase of exposure time from 1 to 4 hours it was found that along with the photolysis of tartaric acid fixation of the nitrogen of the air in the form of amino acid also takes place.

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SOME RESULTS ON GENERALISED k-FUNCTIONS

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1 Chakrabarty (1952) introduced the notation $k_n^l(x)$ which represents the generalised k function of Bateman *viz.*

$$k_n^l(x) = \frac{2}{\pi}\int_0^{\pi/2} 2^l \cos^l\theta \cos(x\tan\alpha - n\theta)\,d\theta \quad l>-1 \qquad (1)$$

In the present note certain formulae and some new recurrence relations involving generalised k-functions have been obtained.

2 Statement of the formulae

(I) $k_n^{1+r}(x) = k_{n+1}^{r}(x) + k_{n-1}^{r}(x) \quad r>-1$

(II) $k_n^{l+r}(x) = k_{n+l}^{r-l+1}(x) + l_{c_1} k_{n+l-2}^{r-l+1}(x) + l_{c_2} k_{n+l-4}^{r-l+1}(x) + \dots + k_{n-l}^{r-l+1}(x)$

where l is a positive integer and $r>l-2$

(III) $k_{2n}^{2l}(x) - 2k_{2n-1}^{2l-1}(x)$

$$= -\tan\alpha\left(\frac{2}{\pi}\right)^{2l+1}\int_0^{\pi/2}\sin(x\tan\alpha - 2n\theta)\cos^{2l}\theta\,d\theta \qquad l>0$$

(IV) $\frac{d}{dx}\left\{k_{2n}^{2l}(x)\right\} = 2k_{2n-1}^{2l-1}(x) - k_{2n}^{2l}(x)$

(V) $k_{2n+1}^{2l+1}(x)\sec^2\alpha - 2k_{2n}^{2l}(x)$

$$= \frac{4}{\pi}\int_0^{\pi} 2^{2l}\cos^{2l}\theta\tan\alpha\sin(x\tan\alpha - 2n\theta)\,d\theta$$

(VI) $\sec^2\alpha\, k_{2n+1}^{2l+1}(x) - 4k_{2n}^{2l}(x) + 4k_{2n-1}^{2l-1}(x) = 0$

(vii) $k^{2l}_{2(m-l)}(x+y) = k^{2l_1}_{2(m-l_1)}(x)\; k^{2l_2}_{-2l_2}(y)$

$+ k^{2l_1}_{2(m-1-l_1)}(x)\, k^{2l_2}_{2(1-l_2)}(y) + k^{2l_1}_{2(m-2-l_1)}(x)\, k^{2l_2}_{2(2-l_2)}(y)$

$+$

$+ k^{2l_1}_{2(1-l_1)}(x)\, k^{2l_2}_{2(m-1-l_2)}(y) + k^{2l_2}_{2(m-l_2)}(y)\; k^{2l_1}_{-2l_1}(x)$

provided $l = l_1 + l_2$

(viii) $k^{2l}_{2(m-l)}(2x) = k^{2l_1}_{2(m-l_1)}(x)\, k^{2l_2}_{-2l_2}(x) + k^{2l_1}_{2(m-1-l_1)}(x)\, k^{2l_2}_{2(1-l_2)}(x) + \dots$

provided $l = l_1 + l_2$

3.1 *Proof of (i)*

We have

$$k^{1+r}_{n} = \frac{2}{\pi}\int_0^{\pi/2} 2^{1+r}\cos^{r+1}\theta\,\cos(x\tan\alpha - n\theta)\,d\theta \quad r>-2$$

$$= \frac{2}{\pi}\int_0^{\pi/2} 2^{r}\cos^{r}\theta\Big[\cos\{x\tan\alpha-(n-1)\theta\}+\cos\{x\tan\alpha-(n+1)\theta\}\Big]d\theta$$

$$= \frac{2}{\pi}\int_0^{\pi/2} 2^{r}\cos^{r}\theta\cos\{x\tan\alpha-(n-1)\theta\}d\theta + \frac{2}{\pi}\int_0^{\pi/2} 2^{r}\cos^{r}\theta\cos\{x\tan\alpha-(n+1)\theta\}d\theta$$

$$= k^{r}_{n+1}(x) + k^{r}_{n-1}(x) \qquad r>-1$$

3.2 Proof of (*ii*)

From (*i*) we have

$$k^{1+r}_{n}(x) = k^{r}_{n+1}(x) + k^{r}_{n-1}(x) \quad r>-1$$

$$= k^{r-1}_{n+2}(x) + k^{r-1}_{n}(x) + k^{r-1}_{n}(x) + k^{r-1}_{n-2}(x) \quad \text{applying (i)} \quad r>0$$

$$= k^{r-1}_{n+2}(x) + 2_{c_1}\, k^{r-1}_{n}(x) + k^{r-1}_{n-2}(x)$$

$$= k^{r-2}_{n+3}(x) + k^{r-2}_{n+1}(x) + 2_{c_1}\, k^{r-2}_{n+1}(x) + 2_{c_1}\, k^{r-2}_{n-1}(x) + k^{r-2}_{n-1}(x) + k^{r-2}_{n-3}(x) \qquad r>1$$

$$= k^{r-2}_{n+3}(x) + 3_{c_1} k^{r-2}_{n+1}(x) + 3_{c_2} k^{r-2}_{n-1}(x) + k^{r-2}_{n-3}(x)$$

$$= k^{r-l+1}_{n+l}(x) + l_{c_1} k^{r-l+1}_{n+l-2}(x) + l_{c_2} k^{r-l+1}_{n+l-4}(x)$$
$$+ \qquad + k^{-l+1}_{n-l}(x)$$

where l is a positive integer and $r > l-2$

3.3 Proof of (*iii*)

In the result

$$e^x k^{2l}_{2n}(x) = \frac{(-1)^{n-l-1}}{\Gamma(2l+2)} (2x)^{2l+1} \; {}_1F_1(l-n+1;\ 2l+2;\ 2x)$$

(Chakrabarty 1955)

putting the value of $k^{2l}_{2n}(\ )$ from (1) and differentiating with respect to 'x' we have,

$$e^x k^{2l}_{2n}(x) - 2\frac{e^x \tan\alpha}{\pi}\int_0^{\pi/2} 2^{2l}\sin(x\tan\alpha - 2n\theta)\cos^{2l}\theta\, d\theta$$

$$= \frac{(-1)^{n-l-1}}{\Gamma(2l+1)}\, 2(2x)^{2l}\; {}_1F_1(l-n+1;\ 2l+1;\ 2x)$$

$$= 2e^x k^{2l-1}_{2n-1}(x) \qquad l>0$$

Hence $k^{2l}_{2n}(x) - 2k^{2l-1}_{2n-1}(x)$

$$= \frac{2^{2l+1}}{\pi}\tan\alpha\int_0^{\pi/2}\sin(x\tan\alpha - 2n\theta)\cos^{2l}\theta\, d\theta \qquad l>0$$

3.4 Proof of (*iv*)

We have

$$k^{2l}_{2n}(x) = \frac{2}{\pi}\int_0^{\pi/2} 2^{2l}\cos^{2l}\theta\cos(x\tan\ \ -2n\theta)\, d\theta$$

Differentiating with respect to x

$$\frac{d}{dx}\left\{k^{2l}_{2n}(x)\right\} = \frac{-2\tan}{\pi}\int_0^{\pi/2}\cos^{2l}\theta\, 2^{2l}\sin(x\tan\alpha - n\theta)\, d\theta$$

$$= 2k^{2l-1}_{2n-1}(x) - k^{2l}_{2n}(x) \quad \text{(from 3.3)}$$

3 5 *Proof of* (*v*)

We have

$$e^x\, k^{2l}_{2n}(x) = \frac{(-1)^{n-l-1}}{\Gamma(2l+2)}\ (2x)^{2l+1}\ {}_1F_1\left(l-n+1;\ 2l+2;\ 2x\right)$$

(Chakrabarty 1953)

or $$e^x\, \frac{2}{\pi}\int_0^{\pi/2} 2^{2l}\cos^{2l}\theta\cos\,(x\tan\alpha-2n\theta) = \frac{(-1)^{n-l-1}\,(2x)^{2l+1}}{\Gamma(2l+2)}\ {}_1F_1\left(l-n+1;\ 2l+2,\ 2x\right)$$

Integrating both sides with respect to x we have

$$\frac{2}{\pi}\int_0^{\pi/2} \frac{2^{2l}\cos^{2l}\theta\ e^x}{(1+\tan^2\alpha)}\left\{\cos\,(x\tan\alpha-2n\theta)+\tan\alpha\sin\,(x\tan\alpha-2n\theta)\right\}d\theta$$

$$=\frac{(-1)^{n-l-1}}{2\,\Gamma(2l+3)}\ (2x)^{2l+2}\ {}_1F_1\left(l-n+1;\ 2l+3;\ 2x\right)$$

or $$\frac{e^x}{\sec^2\alpha}\ k^{2l}_{2n}(x)+\frac{2}{\pi}\frac{\tan\alpha}{\sec^2\alpha}\ e^x\int_0^{\pi/2}\sin\,(x\tan\alpha-2n\theta)\,(2\cos\theta)^{2l}d\theta$$

$$=\frac{x}{2}\ k^{2l+1}_{2n+1}(x)$$

or $$k^{2l+1}_{2n+1}(x)\ \sec^2\alpha-2k^{2l}_{2n}(x)$$

$$=\frac{4}{\pi}\int 2^{2l}\cos^{2l}\theta\ \tan\alpha\sin\,(x\tan\alpha-2n\theta)\,d\theta$$

3 6. *Proof of* (*vi*)

Since $$\frac{d}{dx}\ k^{2l}_{2n}(x) = -\tan\alpha.\ \frac{2}{\pi}\int_0^{\pi/2}\cos^{2l}\ 2^{2l}\sin\,(x\tan\alpha-2n\theta)\,d\theta$$

We have

$$k^{2l+1}_{2n+1}(x)\sec^2\alpha-2k^{2l}_{2n}(x) = -2\frac{d}{dx}\ k^{2l}_{2n}(x)$$

$$\sec^2\alpha\ k^{2l+1}_{2n+1}+4k^{2l-1}_{2n-1}(x)-4\ k^{2l}_{2n}(x)=0$$

3 7 *Proof of* (vi)

In the result

$$\sum_{m=0}^{\infty} t^m \; k^{2l}_{2(m-l)}(x) = (1+t)^{2l} \exp\left(\frac{x(t-1)}{t+1}\right) \quad |t| \angle 1$$

(Chakrabarty 1953)

putting $x+y$ for x we get

$$\sum_{m=0}^{\infty} t^m \; k^{2l}_{2(m-l)}(x+y) = (1+t)^{2l} \exp\frac{x(t-1)}{t+1} \exp\frac{y(t-1)}{t+1}$$

If $l = l_1 + l_2$, we can write the above result as

$$\sum_{m=0}^{\infty} t^m \; k^{2l}_{2(m-l)}(x+y) = (1+t)^{2l_1} (1+t)^{2l_2} e^{x(t-1)/(t+1)} e^{y\frac{(t-1)}{t+1}}$$

$$= \sum_{p=0}^{\infty} t^p \, k^{2l_1}_{2(p-l_1)}(x) \times \sum_{q=0}^{\infty} t^q \, k^{2l_2}_{2(q-l_2)}(y)$$

Equating the co-efficients of t^m

$$k^{2l}_{2(m-l)}(x+y) = k^{2l_1}_{2(m-l_1)}(x) \; k^{2l_2}_{-2l_2}(y)$$

$$+ k^{2l_1}_{2(m-1-l_1)}(x) \; k^{2l_2}_{2(1-l_2)}(y) + k^{2l_1}_{2(m-2-l_1)}(x) \; k^{2l_2}_{2(2-l_2)}(y)$$

$$+ \quad \cdots \quad +$$

$$+ k^{2l_1}_{2(1-l_1)}(x) \; k^{2l_2}_{2(m-1-l_2)}(y) + k^{2l_1}_{-2l_1}(x) \; k^{2l}_{2(m-l_2)}(y)$$

provided $l + l_2 = l$.

3 8 *Proof* (vii)

Putting $x = y$ in (vii)

$$k^{2l}_{2(m-l)}(2x) = k^{2l_1}_{2(m-l_1)}(x) \; k^{2l_2}_{-2l_2}(x)$$

$$+ \qquad\qquad + k^{2l}_{-2l}(x) \; k^{2l_2}_{2(m-l_2)}(x)$$

provided $l = l_1 + l_2$.

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SINGULAR INTEGRALS AND INVERSION OF GENERALIZED LAPLACE AND GENERALIZED STIELTJES TRANSFORMS

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1 INTRODUCTION

The Laplace transform in the classical form is

(1 1) $f(s)=\int_0^\infty e^{-st}\,\phi(t)\,dt.$

Meijer (1941) gave a generalization in the form

(1.2) $f(s)=\int_0^\infty e^{-\frac{1}{2}st}\,W_{k+\frac{1}{2},m}(st)\,(st)^{-k-\frac{1}{2}}\,\phi(t)\,dt$

where $W_{k+\frac{1}{2},m}(st)$ denotes Whittaker function If we replace $k+\frac{1}{2}$ by k in (1 2) we get the transform

(1 3) $f(s)=\int_0^\infty e^{-\frac{1}{2}st}\,W_{k,m}(st)\,(st)^{-k}\,\phi(t)\,dt$

Varma (1951) introduced another general zation in the form

(1 4) $f(s)=\int_0^\infty e^{-\frac{1}{2}st}\,W_{k,m}(st)\,(st)^{m-\frac{1}{2}}\,\phi(t)\,dt.$

He has also shown that f we take $f(s)$ to be the transform of $\phi_1(t)$ in the sense of (1 4) and $\phi_1(\ )$ to be the transform of ϕ (t in the sense of (1 1) we get

(1.5) $f(\ )=\frac{\Gamma(2m+1)}{\Gamma(m-k+3/2)s}\int_0^\infty F(2m+1\ \ 1\ \ m-k+3/2\ \ -t/s)\,\phi(t)\,dt$

where R $(2m+1)>0$ If $k+m=\frac{1}{2}$ the hypergeometric function degenerates into a binomial expression and we get the ordinary Stieltjes transform

(1 6) $f(s)=\int_0^\infty (\ +t)^{-1}\,\phi(t)\,dt.$

If $k-m=\frac{1}{2}$ $2m+1=\rho$ then also the hypergeometric function degenerates into another binomial expression and we obtain

(1 7) $\Theta(s)=\Gamma^{-1}(\rho)\,s^{-\rho+1}f(s)=\int_0^\infty (s+t)^{-\rho}\,\phi(t)\,dt$

Further Varma has shown that if $f(s)$ be the ordinary Laplace transform of $\phi_1(t)$ and ϕ_1 (be the generalized Laplace transform of $\phi(t)$ we have

(1 8) $f(s)=\frac{\Gamma(2m+1)}{\Gamma(m-k+3/2)}\int_0^\infty t^{-1}\,F(2m+1\ \ 1\ \ m-k+3/2\ \ -s/t)\,\phi(t)\,dt$

If $k+m=\frac{1}{2}$ this also reduces to (1 6)

The transforms (1 5) (1 7) and (1 8) may be considered as generalizations of Stieltjes transform (1 6) since they reduce to (1.6) by suitable changes

In this paper we find singular integrals which serve to invert the generalized Laplace transforms (1.3) and (1 4) and the generalized Stieltjes transforms (1.5) (1 7) and (1 8)

2 Laplace's Asymptotic Evaluation of an Integral

In this section we establish theorems which are more general than those proved by Widder (1941 p 278) The method used is similar to that of the theorems referred

Lemma 2.1 If $a<b$ $0<\gamma$ then (*ibid* p 277)

$$I_n = \int_0^{\infty} e^{-n\gamma(x-a)} \, dx \sim \tfrac{1}{2}(\pi n\gamma)^{\frac{1}{2}} \quad (\to\infty)$$

Theorem 2.1 If

(i) $a<a+\eta<b$

(ii) $\beta(t) \in C^2 (a \leq t \leq a+\eta)$ $\beta'(a)=0$ $\beta''(a)<0$
$\beta(t)$ is non increasing $(a \leq t \leq b)$

(iii) $A(t)$ is continuous in the right hand neighbourhood of $t=a$ and integrable in any finite interval and $A(a)\neq 0$ then

$$(2\ 1) \quad \int_a^b e^{n\beta(t)} A(t)\, dt \sim e^{n\beta(a)} A(a) [-\pi/2n\beta''(a)]^{\frac{1}{2}} \quad (n\to\infty)$$

Proof Let us choose an arbitrary real number ε such that $0<\varepsilon<-\beta''(a)$ Then corresponding to ε we can find a number δ less than η and so small that

$(2\ 2)$ $\beta''(a)-\varepsilon<\beta''(t)<\beta''(a)+\varepsilon<0$
where t lies in the closed interval $(a, a+\delta)$

Now let us consider the integral I

$$= n^{\frac{1}{2}} \int_a^b e^{n[\beta(t)-\beta(a)]} A(t)\, dt = n^{\frac{1}{2}} \int_a^{a+\delta} e^{n[\beta(t)-\beta(a)]} A(t)\, dt +$$

$$n^{\frac{1}{2}} \int_{a+\delta}^b e^{n[\beta(t)-\beta(a)]} A(t)\, dt$$

We have the integral

$$\left| n^{\frac{1}{2}} \int_{a+\delta}^b e^{n[\beta(t)-\beta(a)]} A(t)\, dt \right| \leq n^{\frac{1}{2}} e^{n[\beta(a+\delta)-\beta(a)]} \left| \int_{a+\delta}^b A(t)\, dt \right|$$

which tends to zero as n tends to infinity since $A(t)$ is integrable in any finite interval and

$\beta(a+\delta)-\beta(a) = (\delta^2/2)\beta''(a)+ \ldots$
which for $\beta''(a)$ is negative

Further

$$n^{\frac{1}{2}}\int_a^{a+\delta} e^{n[\beta(t)-\beta(\;)]}\,A(t)\,dt=n^{\frac{1}{2}}\int_a^{a+\delta} e^{n\beta''(\xi)(t-a)^2/2}\,A(t)\,dt,$$

$$(a<\xi<a+\delta)$$

By using (2.2) we have

$$n^{\frac{1}{2}}\int_a^{a+\delta} e^{n[\beta''(a)-\epsilon](t-a)^2/2}\,A(t)\,dt<n^{\frac{1}{2}}\int_a^{a+\delta} e^{\frac{1}{2}n\beta''(\xi)(t-a)^2}\,A(t)\,dt$$

$$<n^{\frac{1}{2}}\int_a^{a+\delta} e^{\frac{1}{2}n[\beta''(\;)+\epsilon](t-a)^2}\,A(t)\,dt.$$

If $U(a, a+\delta)$ and $L(a, a+\delta)$ be the upper and lower bounds of $A(t)$ in $0\leq t\leq a+\delta$ we have

$$n^{\frac{1}{2}}L(a, a+\delta)\int_a^{a+\delta} e^{\frac{1}{2}n[\beta''(a)-\epsilon](t-a)^2}\,dt$$

$$<n^{\frac{1}{2}}\int_a^{a+\delta} e^{\frac{1}{2}n[\beta''(\;)-\epsilon](t-a)^2}\,A(t)\,dt$$

$$<n^{\frac{1}{2}}\int_a^{a+\delta} [\beta(t)-\beta(\;)]\,A(t)\,dt$$

$$<n^{\frac{1}{2}}\int_a^{a+\delta} \tfrac{1}{2}n[\beta''(\;)+\;](t-a)^2\,A(t)\,dt$$

$$<\;^{\frac{1}{2}}\,U(a\;\;a+\delta)\int^{a+\delta} \tfrac{1}{2}\;[\beta''(a)+\epsilon](t-a)^2\,dt$$

By using Lemma 2.1 we have

$$L(a\;\;a+\delta)\,(\pi/2)^{\frac{1}{2}}\,[-\beta''(a)+\epsilon]^{-\frac{1}{2}}$$

$$\leq\varliminf_{n\to\infty} n^{\frac{1}{2}}\int^{\;+\delta} e^{n[\beta(t)-\beta(a)]}\,A(t)\,dt$$

$$\leq U(a\;\;a+\delta)\,(\pi/2)^{\frac{1}{2}}\,[-\beta''(a)-\;]^{-\frac{1}{2}}$$

Since δ and are arbitrary and $A(t)$ is continuous in the right hand neighbourhood of $t=a$, we have

$$\lim_{n\to\infty} n^{\frac{1}{2}}\int_a^{a+\delta} e^{n[\beta(t)-\beta(a)]}\,A(t)\,dt=A(\;)\,(\pi/2)^{\frac{1}{2}}\,[-\beta''(a)]^{-\frac{1}{2}}$$

Hence (2.1) is proved

Theorem 2.2. If

(i) $a<a+\eta<b$

(ii) $\beta(t)\in C^2$ $(a\leq t\leq a+\eta)$ $\beta(\;)=0$ $\beta''(\;)<0$ $\beta(t)$ is non-increasing $(a\leq t\leq b)$

(iii) $A(t)$ is continuous in some right hand neighbourhood of $t=$ and integrable in any finite interval and $A(a)\neq 0$

(iv) $\phi(t) \in L\ (a \leq t \leq b)\ \phi(a) \neq 0$

(2.3) $\alpha(t) = \int_a^t [\phi(u) - \phi(a)]\, du = o\,(t-a) \qquad (t \to a+)$

then

(2.4) $\int_a^b \phi(t)\, e^{n\beta(t)}\, A(t)\, dt$

$$\sim \phi(a)\, e^{n\beta(a)}\ A(a)\, (\pi/2n)^{\frac{1}{2}}\, [-\beta''(a)]^{-\frac{1}{2}} \qquad (n \to \infty)$$

Proof Let us set

$$I_n = n^{\frac{1}{2}} \int_a^b [\phi(t) - \phi(a)]\, e^{n[\beta(t) - \beta(\ )]}\, A(t)\, dt$$

Define ε as in the proof of the last theorem. Now Let us choose δ so that (2.2) holds and

$$|\alpha(t)| < \varepsilon\,(t-a) \qquad (a \leq t \leq a+\delta)$$

Let also

$$I_n = I_n' + I_n''$$

where I' and I''_n correspond to the intervals $(a\ a+\delta)$ and $(a+\delta\ b)$ respectively Then

$$|I_n''| \leq n^{\frac{1}{2}}\, e^{n[\beta(a+\delta) - \beta(a)]}\ \underset{a+\delta \leq t \leq b}{\text{l u b}}\ |A(t)| \int_{a+\delta}^b |\phi(t) - \phi(b)|\, dt$$

$$= o\,(1) \qquad (\ \to \infty)$$

Also

$$|I_n'| \leq \underset{a \leq t \leq a+\delta}{\text{l u b}}\ |A(t)|\ \left| \left[n^{\frac{1}{2}}\ e^{n[\beta(t) - \beta(a)]} \int_a^t [\phi(t) - \phi(a)]\, dt \right]_a^{a+\delta} - \right.$$

$$\left. - n^{\frac{1}{2}} \int_a^{a+\delta} (d/dt) \left(e^{n[\beta(t) - \beta(a)]} \right) \left[\int_a^t [\phi(t) - \phi(a)]\, dt \right] dt \right|$$

$$\leq \underset{a \leq t \leq a+\delta}{\text{l u.b}}\ |A(t)|\ \left| n^{\frac{1}{2}}\ e^{n[\beta(a+\delta) - \beta(a)]}\, \alpha(a+\delta) - \right.$$

$$\left. - n^{3/2} \int_a^{a+\delta} \beta'(t)\, e^{n[\beta(t) - \beta(a)]}\, \alpha(t)\, dt \right|$$

$$\leq \underset{a \leq t \leq a+\delta}{\text{l u.b}}\ |A(t)|\ |\ o\,(1) - I_n'''\ | \qquad (n \to \infty)$$

where

$$I_n''' = n^{3/2} \int_a^{a+\delta} e^{n[\beta(t) - \beta(a)]}\, \alpha(t)\, \beta'(t)\, dt$$

Therefore by use of (2.2) (2.3) and $\beta'(t)=\beta''(\xi)(t-a)$ $(a<\xi<t<a+\delta)$ we obtain

$$\left| I_n'' \right| \leq \left| {}^{3/2} \epsilon \int_a^{a+\delta} (t-) e^{\frac{1}{2}n[\beta''(a)+\epsilon](t-a)} [-\beta''(a)+\epsilon] \, dt \right|$$

By making the change of variable

$n^{\frac{1}{2}}[-\beta''(a) -]^{\frac{1}{2}} (t-a)=x$ we have

$$\left| I_n'' \leq \epsilon \left| [-\beta''(a)+\epsilon][-\beta''(a)-\epsilon]^{\frac{1}{2}} \int_0^\infty t^a e^{-\frac{1}{2}t} dt \right| \right.$$

or $\lim_{n\to\infty} I_n'' =0$ since ϵ is arbitrary

Therefore $\lim_{n\to\infty} I_n =0$

and (2.4) is established.

Corollary 2 2 If

(i) $a<b-\eta<b$

(ii) $\beta(t)$ $C^2(b-\eta \leq t \leq b)$ $\beta'(b)=0$ $\beta''(b)<0$ $\beta(t)$ is non-decreasing in $(a \leq t \leq b)$

(iii) $A(t)$ is continuous in some left hand neighbourhood of $t=b$ and integrable in any finite interval,

(iv) $\phi(t)$ L in $(\leq t \leq b)$ $\phi(b) \neq 0$

$$\kappa(t) = \int_t^b [\phi(u)-\phi(b)] \, du = o(b-t) \quad (t\to b-)$$

then

$$\int_a^b \phi(t) \quad {}^{\beta(t)} A(t) \, dt \sim \phi(b) \, e^{\beta(b)} (\pi/2n)^{\frac{1}{2}} [-\beta''(b)]^{-\frac{1}{2}} A(b) \, (n\to\infty)$$

3 A Singular Integral

W now pply the results proved above to an integral which serves to invert the generalized Laplace transforms (1.3) and (1 4)

Theorem 3.1 If

( ) $\phi(t) \in L\ (0< \leq t \leq R)$ fo a fixed s and every larger R

(ii) $\int^{\infty} e^{- t} \phi(t) \, dt$ converges for a fixed positive constant c

(iii) $\int_s^t [\phi(u)-\phi(s)] \, du=o(t-s) \qquad (t\to s+)$

(iv) $\phi(t) \in L\ (a \leq t \leq b)\ \phi(a) \neq 0$

(2.3) $\alpha(t) = \int_a^t [\phi(u) - \phi(a)]\, du = o(t-a) \qquad (t \to a+)$

then

(2.4) $\int_a^b \phi(t)\, e^{n\beta(t)}\, A(t)\, dt$

$$\sim \phi(a)\, e^{n\beta(a)}\, A(a)\, (\pi/2n)^{\frac{1}{2}}\, [-\beta''(a)]^{-\frac{1}{2}} \qquad (n \to \infty)$$

Proof Let us set

$$I_n = n^{\frac{1}{2}} \int_a^b [\phi(t) - \phi(a)]\, e^{n[\beta(t) - \beta(a)]}\, A(t)\, dt.$$

Define as in the proof of the last theorem Now Let us choose δ so that (2.2) holds and

$$|\alpha(t)| < \epsilon\, (t-a) \qquad (a \leq t \leq a+\delta)$$

Let also

$$I_n = I' + I_n$$

where I_n and I_n correspond to the intervals $(a, a+\delta)$ and $(a+\delta\ b)$ respectively Then

$$\Big| I \Big| \leq \tfrac{1}{2}\, e^{n[\beta(a+\delta) - \beta(a)]}\ \underset{a+\delta \leq t \leq b}{\text{l.u.b.}}\ |A(t)| \int_{a+\delta}^b |\phi(t) - \phi(b)|\, dt$$

$$= o(1) \qquad (\ \to \infty)$$

Also

$$I_n \Big| \leq \underset{a \leq t \leq a+\delta}{\text{l u b}}\ |A(t)|\ \Big| \Big[n^{\frac{1}{2}}\, e^{\ [\beta(t) - \beta(a)]} \int_a^t [\phi(t) - \phi(a)]\, dt \Big]_a^{a+\delta} -$$

$$- n^{\frac{1}{2}} \int_a^{a+\delta} (d/dt) \left({}^{n[\beta(t) - \beta(a)]} \right) \Big[\int_a^t [\phi(t) - \phi(a)]\, dt \Big] dt \Big|$$

$$\leq \underset{a \leq t \leq a+\delta}{\text{l u.b}}\ |A(t)|\ \Big|\ n^{\frac{1}{2}}\, e^{n[\beta(a+\delta) - \beta(a)]}\, \alpha(a+\delta) -$$

$$- n^{3\ 2} \int_a^{a+\delta} \beta'(t)\, e^{n[\beta(t) - \beta(a)]}\, \alpha(t)\, dt\ \Big|$$

$$\leq \underset{a \leq t \leq a+\delta}{\text{l u.b.}}\ A(t)|\ \Big|\ o(1) - I\ {}^{\prime\prime}_n\ \Big| \qquad (\ \to \infty)$$

where

$$I_n = n^{3/2} \int_a^{a+\delta} {}^{n[\beta(t) - \beta(a)]}\, \alpha(t)\, \beta\ (t)\, dt$$

But

$p_{n+1}/p_n = \left|(n+1)(s+\delta)(m+k+\frac{1}{2}+n)^{-1} \quad ^{-1}(1+1/n)^{m+k+\frac{1}{2}+n} \quad {}^{-(s+\delta)/s}\right|,$

which approaches $(1+\delta/s)\, e^{-\delta/s}$ $(n\to\infty)$

Therefore

$\lim_{n\to\infty} I_n = \lim_{n\to\infty} p_n = 0$ since $(1+\delta/s) \quad ^{-\delta/s} < 1$

Now let us take

$\beta(t) = \log t - s/t$

then

$\beta'(t) = (1/t) - (1/s) < 0 \quad (s<t)$

$\beta'(s) = 0$ and $\beta''(s) = -s^{-2} < 0$

Let also

$A(t) = t^{m+k-\frac{1}{2}}$ and $a = s$ $b = s+\delta$

Then from Theorem 2.2 we ha e the integral

$$I'_n = \Gamma^{-1}(m+k+\tfrac{1}{2}+n)\,(n/\ )^{m+k+\frac{1}{2}+n}\int_s^{s+\delta} e^{-nt/s}\, t^{m+k-\frac{1}{2}+} \quad \phi(t)\, dt$$

$$\sim \Gamma^{-1}(m+k+\tfrac{1}{2}+\ )(n/\ )^{m+k+\frac{1}{2}+} \quad s^{m+k-\frac{1}{2}} \quad {}^{-n} s^{n} \quad (\pi s^2/2n)^{\frac{1}{2}}\phi(s)(n\to\infty)$$

$$= \tfrac{1}{2}\phi(s)\ e^{-n} \quad n^{m+k+n}(2\pi)^{\frac{1}{2}}\ \Gamma^{-1}(m+k+\tfrac{1}{2}+n) \sim \tfrac{1}{2}\phi(\ )$$

since

$$\Gamma(m+k+\tfrac{1}{2}+n) \sim \quad e^{-m-k-\frac{1}{2}-n}(m+k+\tfrac{1}{2}+n)^{m+k+n}(2\pi)^{\frac{1}{2}} \quad (n\to\infty)$$

$$= \quad {}^{-m-k-n-\frac{1}{2}} \quad {}^{m+k+} \quad \left(1+\frac{m+k+\frac{1}{2}}{n}\right)^{m+k+} \quad (2\pi)^{\frac{1}{2}}$$

$$\sim \quad - \quad n^{m+k+} \quad (2\pi)^{\frac{1}{2}} \quad (n\to\infty)$$

This completes the proof of the theorem.

Theorem 3.2. If

(i) $\phi(t)$ $L\ (0< \ \leq t \leq s)$ for fixed s and every smaller positi e

(ii) $\int_{0+} t^{r}\ \phi(t)\ dt$ converges fo a fixed real constant r

(iii) $\int_s^t [\phi(x)-\phi(\ )]\, dx = o(t-s)$ $(t\to s-$

then

$$(3.2)\quad \Gamma^{-1}(m+k+n+\tfrac{1}{2})\ (\ /\ )^{m+k+\frac{1}{2}+} \quad \int_{0+} e^{-\ t/s}\ t^{m+k-\frac{1}{2}+} \quad \phi(t)\, dt$$

$$\sim \tfrac{1}{2}\phi(s) \qquad (n\to\infty)$$

Proof. Let us choose any positive $\delta < s$ and let us set

$$\alpha(x) = \int_x^{s-\delta} t^r \phi(t)\, dt \quad (0 < x \leq s-\delta)$$

Then there exists a constant M such that $|\alpha(x)| \leq M$ $(0 < x \leq s-\delta)$

Let us set

$$I_n = \Gamma^{-1}(m+k+\tfrac{1}{2}+n)\,(n/s)^{m+k+\frac{1}{2}+n} \int_{0+}^{s-\delta} e^{-nt/s}\, t^{m+k+n-\frac{1}{2}}\, \phi(t)\, dt$$

$$= \Gamma^{-1}(m+k+\tfrac{1}{2}+n)\,(n/s)^{m+k+\frac{1}{2}+n} \int_{0+}^{s-\delta} e^{-nt/s}\, t^{m+k+n-\frac{1}{2}-r}\, d\alpha(t)$$

$$= \Gamma^{-1}(m+k+\tfrac{1}{2}+n)\,(n/s)^{m+k+\frac{1}{2}+n} \Big[e^{-nt/s}\, t^{m+k-\frac{1}{2}+n-r}\, \alpha(t) \Big]_{0+}^{s-\delta}$$

$$- \Gamma^{-1}(m+k+\tfrac{1}{2}+n)\,(n/s)^{m+k+\frac{1}{2}+n} \int_{0+}^{s-\delta} \alpha(t)\, d\Big[e^{-nt/s}\, t^{m+k-\frac{1}{2}+n-r} \Big]$$

$$= -\Gamma^{-1}(m+k+\tfrac{1}{2}+n)\,(n/s)^{m+k+\frac{1}{2}+n} \int_{0+}^{s-\delta} \alpha(t)\, d\Big[e^{-nt/s}\, t^{m+k-\frac{1}{2}+n-r} \Big]$$

Now consider the function

$$V = e^{-nt/s}\, t^{m+k-\frac{1}{2}+n-r}$$

$|V|$ as a function of t is only maximum at

$t = (m' + k' - \tfrac{1}{2} + n - r)\, s/n = \left(1 + \dfrac{m'+k'-\frac{1}{2}-r}{n} \right) s$ $\quad (m' = \text{Re } m,\ k' = \text{Re } k)$

$> s-\delta$ for $n > n_0$,

where n_0 is sufficiently large.

This shows that $|V|$ is non-decreasing $0 \leq t \leq s-\delta$ when $n > n_0$

Hence

$$|I_n| \leq \left| \Gamma^{-1}(m+k+\tfrac{1}{2}+n)\,(n/s)^{m+k+\frac{1}{2}+n}\, M e^{-n(s-\delta)/s}\, (s-\delta)^{m+k-\frac{1}{2}+n-r} \right| \quad (n > n_0)$$

Therefore as in Theorem 3.1

$$\lim_{n\to\infty} I_n = 0$$

Then by Corollary 2.2 we have

$$I_n = \Gamma^{-1}(m+k+\tfrac{1}{2}+n)\,(n/s)^{m+k+\frac{1}{2}+n} \int_{s-\delta}^{s} e^{-nt/s}\, t^{m+k-\frac{1}{2}+n}\, \phi(t)\, dt$$

$$\to \tfrac{1}{2}\phi(s) \quad (n \to \infty)$$

Thus the theorem is established

Theorem 3.3 If

(i) $\phi(t) \in L\ (R^{-1} \leq t \leq R)$ for every $R > 1$

(ii) $\int_1^{\infty} \phi(t)\, e^{-ct}\, dt$ converges for a fixed $c > 0$

(iii) $\int_{0+}^{1} \phi(t)\, t^r\, dt$ converges for a fixed r

(iv) $\int_s^t [\phi(u) - \phi(s)]\, du = o(|s-t|)$ $(t \to s)$

then

(3.3) $\Gamma^{-1}(m+k+\frac{1}{2}+n)\ (n/s)^{m+k+\frac{1}{2}+n} \int_0^{\infty} e^{-nt/s}\, t^{m+k-\frac{1}{2}+n}\, \phi(t)\, dt$

$\sim \phi(s)$ $(n \to \infty)$

The proof is obtained by combining the results of Theorems 3.1 and 3.2.

4 Another Singular Integral

In this section we find another singular integral which serves to invert the generalized Stieltjes transforms (1.5) (1.7) and (1.8)

Theorem 4.1 If

(i) $\phi(t) \in L\ (0 < s \leqq t \leqq R)$ for a fixed s and every larger R

(ii) $\int_s^{\infty} t^c\ \phi(t)\, dt$ converges for a fixed real constant c

(iii) $\int_s^t [\phi(u) - \phi(s)]\, du = o\,(t-s)$ $(t \to s+)$

then

(4.1) $$\frac{\Gamma(2n+m+k-\frac{1}{2})}{\Gamma(n+1)\Gamma(n+m+k-3/2)} \int_s^{\infty} \frac{s^{m+k+n-\frac{3}{2}}\, t^n}{(s+t)^{2n+m+k-\frac{1}{2}}}\, \phi(t)\, dt \sim \tfrac{1}{2}\phi(s)\ (n \to \infty)$$

Proof Let us set

$d_n = \Gamma(2n+m+k-\frac{1}{2})/\Gamma(n+1)\,\Gamma(n+m+k+3/2)$ and

$$I_n = d_n \int_{s+\delta}^{\infty} s^{m+k+n-3/2}\, t^n\, (s+t)^{-2n-m-k+\frac{1}{2}}\, \phi(t)\, dt$$

$$I_n = d_n \int_s^{s+\delta} s^{m+k+\ -3/2}\, t^n\, (s+t)^{-2n-m-k+\frac{1}{2}}\, \phi(t)\, dt$$

where δ is positive. Let, also

$$\alpha(t) = \int_s^t u^c\ \phi(u)\, du \quad (s \leqq t < \infty)$$

Hence there exists a constant M such that

$|\alpha(t)| < M$ $(s \leqq t < \infty)$

On integrating by parts, we have

$$I_n = -d_n\, s^{n+m+k-3/2}\,(s+\delta)^{n-c}\,(2s+\delta)^{-2n-m-k+\frac{1}{2}}\,\alpha\,(s+\delta) -$$

$$-d_n \int_{s+\delta}^{\infty} s^{n+m+k-3/2}\,\alpha\,(t)(d/dt)\left[t^{n-c}\,(s+t)^{-2n-m-k+\frac{1}{2}}\right] dt \quad \text{if}$$

$\mathrm{Re}\,(n+c+m+k-\frac{1}{2}) > 0$

Let us set

$$P = t^{n-c}\,(t+s)^{-2\;\;-m-k+\frac{1}{2}}$$

$|P|$ as a function of t is maximum at

$$t = (n-c)\,s/(n+c+m+k-\tfrac{1}{2}) = s(1-c/n)\left(1+\frac{m'+k+c-\frac{1}{2}}{}\right)^{-1}$$

(where $m = \mathrm{Re}\, m$ and $k = \mathrm{Re}\, k) < s+\delta$ for $\;> n_0$ where n_0 is sufficiently large.

This shows that $|P|$ is decreasing in $(s+\delta \leqq t < \infty)$ where $\;> n_0$.

Hence

$$\left| I_n \right| \leqq M \left| d\;\; s^{\;\;+m+k-3/2}\,(s+\delta)^{n-c}\,(2s+\delta)^{-2n-m-k+\frac{1}{2}} \right| +$$

$$+ M \left| d_n\;\; s^{n+m+k-3/2}\,(s+\delta)^{n-c}\,(2s+\delta)^{-2n-m-k+\frac{1}{2}} \right| = p_n \text{ (say)}$$

But we have $p_{n+1}/p_n =$

$$= \left| s\;(\;+\delta)\;(2s+\delta)^{-2}\,(2n+m+k-\tfrac{1}{2})(2n+m+k+\tfrac{1}{2})/(n+1)\;(n+m+k-3/2) \right|$$

$$\rightarrow \left| 4s\,(s+\delta)\;(2s+\delta)^{-2} \right| \quad 1 \;(n \rightarrow \infty)$$

Hence $\quad I_n \rightarrow 0$ as $n \rightarrow \infty$

Now let us take $\beta\,(t) = \log t - 2 \log (s+t)$

Then we have $\beta'(t) = (1/t) - 2(s+t)^{-1} \;(s < t)$

$$\beta'(\;) = 0 \quad \beta''(s) = -\tfrac{1}{2}\, s^{-2} < 0$$

Let also $\;\psi(t) = s^{m+k-\frac{1}{2}}\,(s+t)^{-m-k+\frac{1}{2}}$

Hence by use of Theorem 2.2 we have

$$I_n + I_n' \frac{\Gamma(2n+m+k-\frac{1}{2})}{\Gamma(n+1)\,\Gamma(n+m+k-3/2} \;\phi(s)s^n\; s^{n-1}\;\; s^{-2n}\;\; (\pi s^2/\;)^{\frac{1}{2}} 2^{\frac{1}{2}-m-k-2n}$$

$$(n \rightarrow \infty)$$

$$\sim \tfrac{1}{2}\phi(s \quad (n \rightarrow \infty)$$

since $\Gamma(\;) \sim \;\;^{-z}\;\;\;^{-\frac{1}{2}}\;\;(2\pi)^{\frac{1}{2}} \quad (\;\rightarrow \infty)$

Thus the theorem is proved.

Theorem 4.2. If

(i) $\phi(t) \in L\;(0 < \epsilon \leqq t \leqq s)$ for a fixed s and every small positive ϵ

(ii) $\int_{0+}^{s} t^{c} \phi(t)\, dt$ converges for a fixed real constant c

(iii) $\int_{s}^{t} [\phi(\;) - \phi(s)]\, dx = 0(-t+\;) \quad (t \to s-)$

then

(4.2) $$\frac{\Gamma(2\;+m+k-\frac{1}{2})}{\Gamma(n+1)\,\Gamma(n+m+k-3/2)} \int_{0}^{s} \frac{s^{m+k+n-3/2}\, t^{n}}{(s+t)^{2n+m+k-\frac{1}{2}}} \phi(t)\, dt$$

$$\sim \tfrac{1}{2}\phi(\;) \qquad (n \to \infty)$$

Proof The hypothesis (ii) implies (Widder 1941 p. 343)

$$\int_{1/s}^{t} \left[x^{-2} \phi(x^{-1}) - s^{2} \phi(s) \right] dx = \left(t - {}^{-1}\right) \left(t \to s^{-1}+\right)$$

By the use of this result our problem is reduced to that of Theorem 4 1 The integral

$$I = \frac{\Gamma(2n+m+k-\frac{1}{2})}{\Gamma(\;+1)\Gamma(n+m+k-3/2)} \int_{0}^{s} \frac{s^{m+k+n-3/2}\, t^{n}}{(s+t)^{2n+m+k-\frac{1}{2}}} \phi(t)\, dt$$

$$= \frac{\Gamma(2n+m+k-\frac{1}{2})\, s^{m+k-5/2}}{\Gamma(n+1)\Gamma(\;+m+k-3/2)} \int_{1/s}^{\infty} \frac{(s^{-1})^{n+m+k-3/2}\, x}{(\;+\;^{-1})^{2n+m+k-\frac{1}{2}}} \left[x^{m+k-5/2} \phi\left(x^{-1} \right) \right] dx$$

Now applying the result of Theorem 4 1 to the above integral we have $I \sim \frac{1}{2} \phi(s) \quad (n \to \infty)$ and th theorem is established.

Theorem 4.3 If

(i) $\phi(t) \in L\left(R^{-1} \leq t \leq R\right)$ for every $R > 1$

(ii) $\int_{1}^{\infty} \phi(t)\, t^{c}\, dt$ converges for a fixed real constant c

(iii) $\int_{0+}^{1} \phi(t)\, t\;\, dt$ converges for a fixed real constant c

(iv) $\int_{s}^{t} [\phi(x) - \phi(t)]\, dx = o(|t-s|) \qquad (t \to\;)$

then

(4.3) $$\frac{\Gamma(2n+m+k-\frac{1}{2})}{\Gamma(\;+1)\,\Gamma(n+m+k-3/2)} \int_{0+}^{\infty} \frac{s^{n+m+k-3/2}\, t^{n}}{(s+t)^{2n+m+k-\frac{1}{2}}} \phi(t)\, dt$$

$$\sim \phi(\;) \qquad (\; \to \infty)$$

By combining the results of Theorems 4 1 and 4.2 we get the result (4.3)

Corollary 4.3a. When $k+m=\frac{1}{2}$ we get the theorem due to Widder (1941 p 344 Theorem 8c)

Corollary 4.3b When $k-m=\frac{1}{2}$ $2m+1=\rho$ we have

If the conditions stated in the theorem given above are satisfied then

$$(4\ 4)\quad \frac{\Gamma(2n+\rho-1)}{\Gamma(n+1)\ \Gamma(n+\rho-2\ )}\int_{0+}^{\infty}\frac{s^{n+\rho-2}\ t^{n}}{(s+t)^{2n+\rho-1}}\phi(t)\ dt \sim \phi(s)\ (n\to\infty)$$

Similarly we can prove the following theorem

Theorem 4 4 If conditions (i) to (i) of Theorem 4.3 are satisfied then

$$(4\ 5)\quad \frac{\Gamma(2n+m+k-\frac{1}{2})}{\Gamma(n+1)\Gamma(\ +m+k-3/2)}\int_{0+}^{\infty}\frac{t^{n+m+k-3/2}\ s^{n}}{(s+t)^{2n+m+k-\frac{1}{2}}}\phi(t)\ dt \sim \phi\ (s)\ (n\to\infty)$$

Corollary 4.4. When $k+m=\frac{1}{2}$ we have the Corollary 4 3a

5 Inversion Operators for Generalized Laplace Lebesgue Integrals

We now define integro-differential inversion operators which serve to invert the generalized Laplace transforms (1.3) and (1 4)

Definition 5 1 An operator $V_{n\,x}\ k(s)$ is defined for any real positive x and any positive integer n by the equation

$$I_{n,x}\ k(s)=\frac{(-1)^{n}\ s^{2m+n+1}}{\Gamma(m+k+n+\frac{1}{2})}D^{n}\ s^{\frac{1}{2}-m-k}\ D^{-n}\ s^{k-m-\frac{1}{2}}\ D^{n}\ k(\ )\Big|_{s=n/x}$$

$$(n=1,2\ 3\quad)$$

It is assumed that the necessary derivatives and integrals exist

Example 5 1 Let us take

$$k(s)=e^{-\frac{1}{2}st}\ (\ t)^{m-\frac{1}{2}}\ W_{k\ m}(st)$$

Now (Goldstein 1932)

$$(5\ 1)\ (d/dx)\quad x^{m-\frac{1}{2}}\ \ -\frac{1}{2}\quad W_{k,m}(x)=-x^{m-1}\ e^{-\frac{1}{2}x}\ W_{k+\frac{1}{2}\ m-\frac{1}{2}}(x)$$

Then on repeated differentiation we have

$$k^{(n)}(s)=(-1)^{n}\ (st)^{m-\frac{1}{2}(n+1)}\ e^{-\frac{1}{2}st}W_{k+\frac{1}{2}n\ m-\frac{1}{2}n}(st)\quad t^{n}$$

$$=(-1)^{n}\ e^{-st}\quad 2m-n\ \Psi\ (\tfrac{1}{2}-k+m-n\ \ 2m-n+1\ \ st)$$

since (Erdelyi, 1953 p 261)

$$(5.2)\quad W_{k\ m}(z)=\ \ -\frac{1}{2}\quad z^{m+\frac{1}{2}}\quad \Psi\ \tfrac{1}{2}-k+m\ 2m+1\quad)$$

where Ψ is a function introduced by Tricomi who denoted it by G

Therefore

$$D^{-n}\ s^{-m+k-\frac{1}{2}}\ k^{\,n)}\ (s)=\ \ ^{-st}\ s^{k+m-\frac{1}{2}}\ \Psi\ (\tfrac{1}{2}-k+m\ \ 2m+1-n\ \ st)$$

by using the result (*ibid* p 258)

(5.3) $\left(d^n/dx \right) \quad ^{-x} \; x^{c-a+\;-1} \; \Psi(a, c \quad) =$

$= (-1)^n \quad e^{-x} \quad x^{c-a-1} \; \Psi(a-n \;\; c \;\; x)$

Also we have (*ibid*, p 258)

(5 4) $\left(d^n/dx^n \right) e^{-x} \Psi(a \;\; c \;\; x) = (-1)^n \quad ^{-x} \; \Psi(\quad +n \;\; x)$

Hence by the use of this result we obtain

$s^{2m+n+1} \quad D \quad s^{-m-k+\frac{1}{2}} \; D^{-n} \quad {}^{-m+k-\frac{1}{2}} \; h^{(n)} \quad (s) =$

$= (-1)^n \quad e^{-\frac{1}{2}st} \; s^{m+n+\frac{1}{2}} \; W_{k,m}(st) \; t^{n+m-\frac{1}{2}}$

Therefore

$V_{\;,n} \; h(t) = \Gamma^{-1}(m+k+n+\frac{1}{2}) \quad (n/x)^{m+\;+\frac{1}{2}} \; W_{k,m}(nt/x) e^{-\frac{1}{2}\,nt/x} \quad t^{m+n-\frac{1}{2}}$

Theorem 5 1 If $\phi(t)$ L in $0 \leqq t \leqq R$ for every positive R and is such that the integral (1 4) converges then

(5 5) $\lim\limits_{n\to\infty} \quad V_{n\;n} \; f(\;) \; = \; \phi(x)$

for all points of x of the Lebesgue set for the function ϕ (t)

Proof We have from Example 5 1

$$V_{n,x} \; f(s) \; = \Gamma^{-1}(m+k+\tfrac{1}{2}+n)(n/x)m+n+\tfrac{1}{2} \int_0^\infty e^{-\frac{1}{2}nt/x} \; W_{k,m}(nt/x) \; t^{m+n+\frac{1}{2}}$$

$$\phi(t) \quad dt.$$

But (Whittaker and Watson, 1946 p 343)

(5 6) $W_{k,m}(z) \quad \sim \quad e^{-\frac{1}{2}z} \; z^k \quad (z\to\infty)$

Therefore

$$V_{n,x} f(\;) \sim \Gamma^{-1}(m+k+\tfrac{1}{2}+\;) \; (\;/x)^{m+k+n+\frac{1}{2}} \int_0^\infty e^{-nt/x} \quad t^{m+k+n-\frac{1}{2}} \; \phi(t) \, dt$$

$$(n\to\infty)$$

Hence by the use of Theorem 3 3 we have

$V_{n,x} \; f(s) \quad \sim \quad \phi(x) \quad (n\to\infty)$

Corollary 5.1. When $k+m=\frac{1}{2}$ we have the theorem due to Widder (Widder 1941 p 288, Theorem 6a)

Definition 5.2. An operator $V^*_{n,x}$ $f(s)$ is defin d for any eal positi e and any pos tive integer n by the equation

$V^* \;_{,n} \quad f(s) = (-1)^n \; \Gamma^{-1}(\; +1) \quad s^{n+m-k+3/2} \; D \quad s^{-m-k+\frac{1}{2}} \; D^{-n}$

$s^{-m+k-\frac{1}{2}} \; D^n \quad s^{k+m-\frac{1}{2}} f(s) \; \Big|_{s=\;\;/}$

Example 5.2. Let us take

$$k(s) = e^{-\frac{1}{2}st} (st)^{-k} W_{k,m}(st)$$

Then by using (5 1) (5.2) (5 3) and (5 4) we have (as in Example 5 1)

$$V_{n,x}\ k(s) = \Gamma^{-1}(n+1)\ (n/x)^{n-k+1}\ e^{-\frac{1}{2}nt/x}\ W_{k,m}(nt/x)\ t^{n-k}$$

Theorem 5 2 If $\phi(t)$ L in $0 \leqq t \leqq R$ for every posit e R and is such that the integral (1 3) converges then

(5 7) $\quad V_{n,x}\ f(s) \sim \phi(x) \quad (n\to\infty)$

at all points of s of the Lebesgue set for the function ϕ (t)

Proof From Example 5 2 we have

$$V_{n,x}\ f(s) = \Gamma^{-1}(\ +1)\ (n/x)^{n-k+1} \int_0^\infty e^{-\frac{1}{2}nt/x}\ W_{k,m}(nt/x)\ t^{n-k}\ \phi(t)\ dt$$

$$\sim \Gamma^{-1}(n+1)\ (n/x)\ ^{+1} \int_0^\infty e^{-nt/x}\ t^n\ \phi(t)\ dt \quad (n\to\infty)$$

$$\sim \phi(x) \quad (n\to\infty)$$

by Theorem 3.3 (after putting $k+m=\frac{1}{2}$)

Corollary 5 2. When $k\pm m=\frac{1}{2}$ we have the result proved in Corollary 5 1

6 The Inversion Operators for Generalized Stieltjes Lebesgue Integrals

We now define the following I tegro-differential operator whicl serves to in ert the transform (1.5)

Definition 6 1 An operator $L_{n,s}\ f(s$ is defined for any real positive s by the equ tions

$$L_{n,s}\ f(\ ) = \frac{\Gamma(2n+m-k+\frac{1}{2})\ \Gamma(2n+m+k-\frac{1}{2})}{\Gamma(2m+2n\ \Gamma(2n)\Gamma(n+1)\Gamma(n+m+k-3/2)}(-1)\ \ ^{-1}$$

$$D^n s^{2n-1}\ D\ ^{-1}\ s^{2n+n-1}\ D^{n-1}\ \ s^{-k-m+\frac{1}{2}}\ D^{-n+1}\ \ s^{-m+k-n+\frac{1}{2}} f(s)$$

$$(n=2,3 \qquad)$$

$L_{1,s}\ f(s) = D\ s\ f(s$

$L_{0,s}\ f(s) = f(\ )$ where $D \equiv d/ds$ and

$$D^{-1}\ s = \int_0^s s^n\ d \quad \text{if Re } (n+1) > 0$$

$$= -\int_s\ s^n\ ds \quad \text{if Re } (n+1) < 0$$

It is assumed that $f(s)$ has derivatives and integrals of all orders.

Exampl 6.1 Let us take

$f(s)=\Gamma(2m+1)\Gamma^{-1}(m-k+3/2)\ s^{-1}\ F(2m+1\ 1\ m-k+3/2\ -t/s)$

Then $s^{k-m-n+\frac{1}{2}} f(\ )=$

$=\Gamma(2m+1)\ \Gamma^{-1}(m-k+3/2)\ s^{-m+k-\ -\frac{1}{2}}\ F(2m+1\ 1\ m-k+3/2\ -t/s)$

By Euler s theorem on homogeneous functions, we have

$(\partial/\partial s)\ s^{-m+k-n+\frac{1}{2}}\ t^{m-k+n-3/2}\ F(2m+1\ 1\ m-k+3/2\ -t/s)=$

$=(-1)\ (\partial/\partial t)\ s^{-m+k-n-\frac{1}{2}}\ t^{m-k+n-\frac{1}{2}}\ F\ 2m+1\ 1\ m-k+3/2\ -t/s)$

or $D^{-1}\ s^{-m+k-n-\frac{1}{2}}\ t^{m-k+n-\frac{1}{2}}\ F(2m+1\ 1\ m-k+3/2\ -t/s)$

$=(-1)\ D^{-1}\ s^{-m+k-n+\frac{1}{2}}\ t^{m-k+n-3/2}\ F(2m+1\ 1\ m-k+3/2\ -t/s)$

where $D\equiv(\partial/\partial\ )$ and $D\equiv(\partial/\partial t)$ On using this theorem repeatedly we have

$D^{1-n}\ s^{-m+k-n-\frac{1}{2}}\ t^{m-k+n-\frac{1}{2}}\ F(2m+1\ 1\ m-k+3/2\ -t/s)$

$=(-1)\ ^{-1}\ D^{1-}\ \ s^{-1}\ (t/\ )^{m-k+\frac{1}{2}}\ F(2m+1\ 1\ m-k+3/2\ -t/s)$

But we have (Erdelyi, 1953 p 102)

(6 1) $(c-n+1)_{n-1}\ z^{c-n}\ F(\ \ b\ c-n+1\ z)$

$=\left(d^{n-1}/dz^{n-1}\right)\ z\ ^{-1}\ F(a\ b\ c\ \ z)$

By the use of (6 1) we have

$(-1)\ ^{-1}\ D^{1-n}\ (t/s)^{c-n}\ \ s^{-1}\ F(a\ b\ c-\ +1\ -t/s)$

$=\dfrac{(-1)^{n-1}}{(-\ +1)_{n-1}}\ s\ ^{-c-1}\ \ t\ ^{-1}\ F(a\ b\ \ \ -t/s)$

Therefore $D^{1-n}\ s^{-m+k-n-\frac{1}{2}}\ t^{m-k+n-\frac{1}{2}}F(2m+1\ 1\ m-k+3/2\ -t/s)$

$=\dfrac{(-1)^{n-1}}{(m-k+3/^{0})_{n-1}}\ t^{m-k+\ -\frac{1}{2}}\ s^{-m+k-3/2}\ F(2m+1\ 1\ m-k+\frac{1}{2}+\ \ -t/s)$

or $s^{\frac{1}{2}-k-m}\ D^{1-n}\ s^{-m+k-\ +\frac{1}{2}}\ f(s)=$

$=(-1\ \ ^{-1}\ \Gamma(2m+1)\ \ \Gamma^{-1}(m-k+\frac{1}{2}+\ )\ s^{-2m-1}\ F(2m+1\ 1\ m-k+\frac{1}{2}+n\ -t/s)$

Similarly by Euler' theorem we have

$D\ (t/\ )^{2m}\ \ s^{-1}\ F(2m+1\ 1\ m-k+\frac{1}{2}+n\ -t/s)=$

$=(-1)\ D\ \ (t/\ )^{2m+1}\ \ s^{-1}\ F(2m+1\ 1\ m-k+\frac{1}{2}+n\ -t/\ )$

Using this theorem repeatedly we have

$D^{n-1}\ (t/s)^{2m\ \ -1}\ F(2m+1\ 1\ m-k+\frac{1}{2}+\ \ \ -t/\ )=$

$=(-1)^{n-1}\ D^{n-1}\ (t/s)^{2m+n-1\ \ -1}\ F(2m+1\ 1\ m-k+\frac{1}{2}+\ \ -t/\ )$

But (*ibid* p. 102)

(6 2) $\left(d^{n-1}/dz^{n-1}\right) z^{a+n-2} F(a \; b \; c \quad)$

$= (a)_{n-1} \; z^{a-1} \quad F(a+n-1 \; b \; c \; z)$

Therefore $D^{n-1} \; s^{-k-m+\frac{1}{2}} \; D^{1-n} \; s^{-m+k-n+\frac{1}{2}} f(s) =$

$= \Gamma(2m+n) \; \Gamma^{-1}(m-k+n+\frac{1}{2}) \; s^{-1} \; F(2m+n, 1 \; m-k+\frac{1}{2}+n \; -t/s)$

Again using Euler s theorem and (6.2) we have

$s^{2n-1} \; D^{n-1} \; s^{2m+n-1} \; D^{n-1} \; s^{-k-m+\frac{1}{2}} \; D^{1-n} \; s^{-m+k-n+\frac{1}{2}} f(s) =$

$= (-1)^{n-1} \; \Gamma(2m+n) \; \Gamma(n) \; \Gamma^{-1}(m-k+\frac{1}{2}+n) \; s^{n-1}$

$F(2m+n \; n \; m-k+\frac{1}{2}+n \; -t/s)$

But we have (*ibid* p. 102)

(6 3) $\left(d^n/d^n\right) F(a, b \; c \quad) = \dfrac{(a)_n \; (b)_n}{(c)_n} F(a+n \; b+n \; c+n \; z)$

Therefore by the use of Euler s theorem and (6 3) we obtain

(6 4) $L_{\;,s} \; f(s) = \Gamma(2n+m+k-\frac{1}{2}) \; \Gamma^{-1}(\; +1) \; \Gamma^{-1}(n+m+k-3/2) \; t^n$

$s^{-n-1} \; F(2m+2n \; 2n \; m-k+\frac{1}{2}+2n \; -t/s) \quad (n=2, 3 \qquad)$

If $k+m=\frac{1}{2}$ we observe that the operator $L_{n,s}$ becomes

$L_{\;,s} \; f(s) = (-1^{\;n-1} \; \Gamma^{-1}(n+1) \; \Gamma^{-1}(\; -1) \; D^n \; s^{2n-1} \; D^{n-1} \; f(s)$

which is the inversion operator for the ordinary Stieltjes transform. (Widder 1941 p 350)

If $k-m=\frac{1}{2}$ $2m+1=\rho$ we see that $L_{n,s}$ takes the form

$L_{n,s} \; f(s) = \dfrac{(-1)^{n-1}}{\Gamma(n+1) \; \Gamma(n+\rho-2)} \; D^n \; s^{2n-1} \; D^{n-1} \; s^{\;+\rho-2} \; D^{n-1} \; s^{1-\rho}$

$D^{1-n} \; s^{1-n} f(s)$

which is the inversion operator for the transform

$f(s) = s^{d-1} \; \Gamma(d) \int_0^\infty (s+t)^{-d} \; \phi(t) \; dt$

or the operator for the transform

$\Theta(s) = \Gamma^{-1}(d) \; s^{1-d} \; f(s) = \int_0^\infty (s+t)^{-\rho} \; \phi \; t) \; dt$

is

$L_{\;n\;s} \; \Theta(s) = \dfrac{(-1)^{n-1} \; \Gamma(\rho)}{\Gamma(n+1) \; \Gamma(n+\rho-2)} \; D^n \; s^{2n-1} \; D^{n-1} \; s^{n+\rho-2} \; D^{n-1} \; s^{1-d}$

$D^{1-n} \; s^{2-n-\rho} \; \Theta(s)$

The operator $L_{n,s} f(s)$ can take various forms and a few of them are given below:

$$L_{n,s} f(s) = \frac{\Gamma(2n+m-k+\frac{1}{2})\ \Gamma(2n+m+k-\frac{1}{2})}{\Gamma(2m+2n)\ \Gamma(n+1)\ \Gamma(2n)\ \Gamma(n+m+k-3/2)} (-1)^{n-1}\ P_{n,s} f(s)$$

where

$$P_{n,s} f(s) = s^{m-k+\frac{1}{2}} D^{1-n}\ s^{m+k-\frac{1}{2}}\ D^{n-1}\ s^{n-2m-1}\ D^{2n-1}\ s^{n} f(s)$$

$$= s^{m-k+\frac{1}{2}}\ D^{1-n}\ s^{m+k-\frac{1}{2}}\ D^{n-1}\ s^{-2m}\ D^{n}\ s^{2n-1} f^{(n-1)}\ (s)$$

$$= D^{n}\ s^{2n-1}\ D^{n-1}\ s^{2m+n-1}\ D^{n-1}\ s^{-m-k+\frac{1}{2}}\ D^{1-n}\ s^{-m+k-n+\frac{1}{2}} f(s)$$

If $k+m=\frac{1}{2}$ then these all forms reduce to either

$$\frac{(-1)^{n-1}}{\Gamma(n+1)\,\Gamma(n-1)}\ D^{n}\ s^{2n-1}\ f^{(n-1)}\ (s) \text{ or } \frac{(-s)^{n-1}}{\Gamma(n+1)\,\Gamma(n-1)} D^{2n-1}\ s^{n} f(s)$$

which are inversion operators for the ordinary Stieltjes transform

Theorem 6.1. If $\phi(t) \in L$ in $0 \leqq t \leqq R$ for every $R > 0$ and is such that the integral (1.5) converges, then

(6.5) $\quad L_{n,s} f(s) \to \phi(s) \quad (n \to \infty)$

at all points of s in the Lebesgue set for the function $\phi(t)$

Proof We have from (6.4)

$$L_{n,s} f(s) = \Gamma(2n+m+k-\tfrac{1}{2})\ \Gamma^{-1}(n+1)\ \Gamma^{-1}(n+m+k-3/2)$$

$$\int_0^{\infty} t^{n}\ s^{-n-1}\ F(2m+2n, 2n\ m-k+\tfrac{1}{2}+2n\ -t/s)\ \phi(t)\ dt$$

Now we have (Erdélyi 1953 p. 105)

$$F(2m+2n\ 2n\ m-k+\tfrac{1}{2}+2n\ -t/s) = (1+t/s)^{-m-k+\frac{1}{2}-2n}\ F(-m-k+\tfrac{1}{2}\ m-k+\tfrac{1}{2}\ m-k+\tfrac{1}{2}+2n\ -t/s)$$

and (ibid p. 76) $F(-m-k+\frac{1}{2}\ m-k+\frac{1}{2};\ m-k+\frac{1}{2}+2n\ -t/s) =$

$$= 1+0\left(\left|m-k+\tfrac{1}{2}+2n\right|^{-1}\right) \quad (n \to \infty)$$

Then $F(-m-k+\frac{1}{2}\ m-k+\frac{1}{2}\ m-k+\frac{1}{2}+2n\ -t/s) \sim 1 \quad (n \to \infty)$

Therefore

$$L_{\ ,s} f(\ ) \sim \frac{\Gamma(2n+m+k-\frac{1}{2})}{\Gamma(n+1)\Gamma(\ +m+k-3/2)} \int_0^{\infty} \frac{t^{n}\ s^{n+m+k-3/2}}{(s+t)^{2n+m+k-\frac{1}{2}}}\ \phi(t)\ dt \quad (n \to \infty)$$

Now we apply the result of Theorem 4.3 and obtain

$L_{n,s} f(s) \sim \phi(s) \quad (n \to \infty)$

To satisfy the conditions of Theorem 4.3, let us set

$$a(x) = \Gamma(2m+1)\Gamma^{-1}(m-k+3/2) \int_s^{x} F(2m+1\ \ 1\ \ m-k+3/2;\ s-t)\ \phi(t)\ dt$$

The function $\alpha(x)$ approaches a finite limit as x becomes infinite since (1.5) converges. Then

$$\int_1^{\infty} t^{-1}\,\phi(t)\,dt = \Gamma(m-k+3/2)\,\Gamma^{-1}(2m+1)\int_1^{\infty} t^{-1}\,F(2m+1\;1;m-k+3/2\;-t)\,d\alpha(t)$$

$$=\frac{\Gamma(m-k+3/2)}{\Gamma(2m+1)}\left[\alpha(t)\frac{1}{t\,F(2m+1\;1\;m-k+3/2\;-t)}\right]_1^{\infty}-$$

$$-\int_1^{\infty}\alpha(t)\;(d/dt)\left[\frac{1}{t\,F\,(2m+1\;1\;m-k+3/2;-t)}\right]dt$$

The integral

$$I=\int_1^{\infty}\alpha(t)\;(d/dt)\;[t\;F(2m+1\;1;m-k+3/2\;-t)]^{-1}\;dt$$

converges since

$$|I|\leqq M\left|\int_1^{\infty}(d/dt)\left[\frac{1}{t\,F(2m+1\;1;m-k+3/2\;-t)}\right]dt\right|$$

$$\leqq M\left|\lim_{t\to\infty}\frac{1}{t\,F(2m+1\;1\;m-k+3/2\;-t)}-\frac{1}{F(2m+1\;1\;m-k+3/2\;-1)}\right|$$

where $M = \text{l.u.b.}\;|\alpha(t)|$
$\qquad 1\leqq t<\infty$

which clearly exists since (1.5) converges.

Also by using relations (17) (18) and (19) (Erdélyi etc. 1953 p 63) we can show that

$$\lim_{t\to\infty}\left[\frac{1}{t\,F(2m+1\;1\;m-k+3/2;-t)}\right]$$

is always a finite quantity

Hence c (of Theorem 4.3) may be taken as -1. Also c' may be taken as zero since $\phi(t)\in L$ in $0\leqq t\leqq R$ for every positive R.

This completes the proof of this theorem.

Corollary 6 1a When $k+m=\frac{1}{2}$ we have the theorem due to Widder (Widder 1941 p. 345 Theorem 9)

Corollary 6 1b When $k-m=\frac{1}{2}$ $2m+1=\rho$ we have:

If $\phi(t)\in L$ in $0\leqq t\leqq R$ for positive R and n such that the integral (1 7) converges then

(6.7) $L_{n,t}\;\Theta(s)\sim\phi(s)\qquad(n\to\infty)$

at all points of s in the Lebesgue set for the function $\phi(t)$

Example 6.2. Let us set $\phi(t) = t^{a}$. Then

$$L_{n,s} f(s) = \Gamma(2n+m+k-\tfrac12)\Gamma^{-1}(n+1)\Gamma^{-1}(n+m+k-3/2) \int_0^\infty t^{a+n} s^{-1-n} F(2m+2n, 2n; m-k+\tfrac12+2n; -t/s)\,dt$$

$$= s^{a}\, \frac{\Gamma(2n+m+k-\frac12)\,\Gamma(2m+n-a-1)\,\Gamma(n-a-1)\,\Gamma(2n+m-k+\frac12)\,\Gamma(a+n)}{\Gamma(n+1)\,\Gamma(n+m+k-3/2)\,\Gamma(2m+2n)\,\Gamma(2n)\,\Gamma(m-k-\frac12+n-a)}$$

provided that $\mathrm{Re}(a+n+1) > 0$, $\mathrm{Re}(2m+n-a-1)>0$, $\mathrm{Re}(n-a-1)>0$ and $m-k+3/2 \neq 0, -1, -2,$ since (Erdélyi 1953 p. 79)

$$(6.8) \quad \int_0^\infty z^{-d-1} F(a, b; c; -z)\,dz = \frac{\Gamma(a+d)\,\Gamma(b+d)\,\Gamma(c)\,\Gamma(-d)}{\Gamma(a)\,\Gamma(b)\,\Gamma(c+d)}$$

provided that $\mathrm{Re}(a+d)>0$, $\mathrm{Re}(b+d) >0$, $\mathrm{Re}\, d<0$ and $c\neq 0, -1, -2, ..$

Therefore $L_{n,s} f(s) \sim s^{a}$ $(n\to\infty)$ for

$$(6.9) \quad \Gamma(z+a)\,\Gamma^{-1}(z+b) \sim z^{a-b} \qquad (|z| \to\infty)$$

We now define an integro-differential operator which serves to invert the transform (1.8).

Definition 6.2. An operator $U_{n,s} f(s)$ is defined for any real positive s by the equations

$$U_{n,s} f(s) = (-1)^{n-1}\Gamma^{-1}(n+1)\,\Gamma^{-1}(n-1)\, n^{-m-k+\frac12}\, s^{-n-m+k-\frac12}\, D^{-n}\, s^{-m-k+\frac12}\, D^{n}\, s^{2m+n}\, D^{n}\, s^{2n-1} f^{(n-1)}(s) \quad (n=2,3, \ldots)$$

$$= D\, s\, f(s) \qquad (n=1) \quad \text{where } D \equiv (d/ds)$$

It is assumed that the necessary derivatives and integrals exist.

Example 6.3. Let us take

$$f(s)=\Gamma(2m+1)\,\Gamma^{-1}(m-k+3/2)\, t^{-1} F(2m+1, 1; m-k+3/2; -s/t)$$

Then using (6.3) we have

$$s^{2n-1} f^{(n-1)}(s) = (-1)^{n-1}\, \Gamma(2m+n)\,\Gamma(n)\,\Gamma^{-1}(m-k+\tfrac12+\ )\, s^{2n-1}\, t^{-n-1} F(2m+n, n; m-k+\tfrac12+n; -s/t)$$

Similarly by the use of (6.2) we obtain

$$s^{2m+n} D^{n} s^{2n-1} f^{(n-1)}(s) = (-1)^{n-1}\, \Gamma(2m+n)\,\Gamma(2n)\,\Gamma^{-1}(m-k+\tfrac12+n)\, s^{2n+2m-1}\, t^{-n-1} F(2m+n, 2n; m-k+\tfrac12+n; -s/t)$$ and

$$s^{-m-k+\frac12} D^{n} s^{n+2m} D^{n} s^{2n-1} f^{(n-1)}(s) = (-1)^{n-1}\,\Gamma(2m+2n)\,\Gamma(2n)\,\Gamma^{-1}(m-k+\tfrac12+n)\, s^{m-k+\ -\frac12}\, t^{-n-1} F(2m+2n, 2n; m-k+\tfrac12+n; -s/t)$$

Again by using (6.1) we have

$$s^{-n-m+k-\frac12} D^{-n} s^{-m-k+\frac12} D^{n} s^{2m+n} D^{n} s^{2n-1} f^{(n-1)}(s) = (-1)^{n-1}\,\Gamma(2m+2n)\,\Gamma(2n)\,\Gamma^{-1}(m-k+\tfrac12+2n)\, s\ t^{-\ -1} F(2m+2n, 2n; m-k+\tfrac12+2n; -s/t)$$

The function $a(x)$ approaches a finite limit as x becomes infinite since (1.5) converges. Then

$$\int_1^{\infty} t^{-1}\,\phi(t)\,dt = \Gamma(m-k+3/2)\,\Gamma^{-1}(2m+1)\int_1^{\infty} t^{-1}\;{}_1F(2m+1\;\;1\;\;m-k+3/2\;\;-t)\,da(t)$$

$$= \frac{\Gamma(m-k+3/2)}{\Gamma(2m+1)}\left[a(t)\,{}_1F(2m+1\;\;1\;\;m-k+3/2\;\;-t)\right]_1^{\infty} -$$

$$-\int_1^{\infty} a(t)\;(d/dt)\left[{}_1F\,(2m+1\;\;1;\;m-k+3/2;-t)\right]dt$$

The integral

$$I = \int_1^{\infty} a(t)\;(d/dt)\;[{}_1F(2m+1\;\;1\;\;m-k+3/2\;\;-t)]^{-1}\;dt$$

converges since

$$|I| \leqq M\left|\int_1^{\infty} (d/dt)\left[{}_1F(2m+1\;\;1\;\;m-k+3/2\;\;-t)\right]dt\right|$$

$$\leqq M\;\left|\lim_{t\to\infty}\;{}_1F(2m+1\;\;1\;\;m-k+3/2\;\;-t) - {}_1F(2m+1\;\;1\;\;m-k+3/2\;\;-1)\right|$$

where $M = \underset{1 \leqq t < \infty}{\text{l.u.b}}\; |a(t)|$

which clearly exists since (1.5) converges.

Also by using relations (17) (18) and (19) (Erdélyi etc. 1953 p 63) we can show that

$$\lim_{t\to\infty}\left[{}_1F(2m+1\;\;1;\;m-k+3/2\;\;-t)\right]$$

is always a finite quantity

Hence c (of Theorem 4.3) may be taken as -1. Also c' may be taken as zero since $\phi(t) \in L$ in $0 \leqq t \leqq R$ for every positive R.

This completes the proof of this theorem.

Corollary 6 1a When $k+m=\frac{1}{2}$ we have the theorem due to Widder (Widder 1941 p. 345 Theorem 9)

Corollary 6 1b When $k-m=\frac{1}{2}$ $2m+1=\rho$ we have :

If $\phi(t) \in L$ in $0 \leqq t \leqq R$ for positive R and is such that the integral (1 7) converges then

(6.7) $L_{n,t}\;\Theta(t) \sim \phi(t) \qquad (n\to\infty)$

at all points of t in the Lebesgue set for the function $\phi(t)$

$$\leqq \left| d_n \varepsilon \int_0^{\delta} t^{n-1} x^{-n} F(2m+2n, 2n, m-k+\tfrac{1}{2}+2n, -t/x)\, dt \right| +$$

$$+ \left| d_n x M \int_{\delta}^{\infty} t^{n} x^{-n-1} F(2m+2n, 2n, m-k+\tfrac{1}{2}+2n, -t/x)\, dt \right|$$

where

$$M = \underset{\delta \leqq t < \infty}{\text{l u b.}} \left| [\alpha(t) - \alpha(0+)]\, t^{-1} \right|$$

when (Arya, 1958 Theorem 3 1)

(7.3a) $\alpha(t) = o(t) \quad (t \to \infty)$ if

(i) $2m$ is positive integer

or (ii) $2m \neq 0$ or positive integer $k \pm m \neq \frac{1}{2}$ Re $m \geqq 0$

or (iii) $k+m=\frac{1}{2}$

Hence in these cases $| I(x) | \leqq$

$$\leqq \left| d_n \int_0^{\delta/x} u^{n-1} F(2m+2n, 2n, m-k+\tfrac{1}{2}+2n, -u)\, du \right| +$$

$$+ \left| d_n M x \int_{\delta/x}^{\infty} u^{n} F(2m+2n, 2n, m-k+\tfrac{1}{2}+2n, -u)\, du \right|$$

Now let us consider the case when (Arya, 1958 Theorem 3 1)

(7.3b) $\alpha(t) = o\left(t^{2m+1}\right) \quad (t \to \infty)$

if (i) $k-m=\frac{1}{2}$

or (ii) $2m \neq 0$ or a positive integer $k \pm m \neq \frac{1}{2}$ Re $m<0$ and let in these cases

$$M' = \underset{\delta \leqq t < \infty}{\text{l u.b}} \left| [\alpha(t) - (0+)]\, t^{-2m-1} \right|$$

Then we have $| I(x) | \leqq$

$$\leqq \left| d_n \varepsilon \int_0^{\delta} t^{n-1} x^{-n} F(2m+2n, 2n, m-k+\tfrac{1}{2}+2n, -t/x)\, dt \right| +$$

$$+ \left| d_n x^{2m+1} M' \int_{\delta}^{\infty} t^{2m+n} x^{-n-1-2m} F(2m+2n, 2n, m-k+\tfrac{1}{2}+2n, -t/x) dt \right|$$

$$\leqq \varepsilon \left| d_n \int_0^{\delta/x} u^{n-1} F(2m+2n, 2n, m-k+\tfrac{1}{2}+2n, -u)\, du \right| +$$

$$+ M' \left| x^{2m+1} d \int_{\delta/x}^{\infty} u^{2m+n} F(2m+2n, 2n, m-k+\tfrac{1}{2}+2n, -u)\, du \right|.$$

Since ε is arbitrary

$$\limsup_{x \to 0+} | I(\ ) | = 0$$

in both the cases mentioned above.

Hence we have

$$d_n \int_0^\infty t^{n-1} x^{-n} F(2m+2n, 2n, m-k+\tfrac{1}{2}+2n, -t/x)\, \alpha(t)\, dt$$

$$\sim \alpha(0+)\, d_n \int_0^\infty t^{n-1} x^{-n} F(2m+2n, 2n, m-k+\tfrac{1}{2}+2n, -t/x)\, dt$$

$$\sim \alpha(0+) \frac{\Gamma(n)\, \Gamma(2m+n)\, \Gamma(m-k+\frac{1}{2}+2n)\, \Gamma(2n+m+k-\frac{1}{2})}{n\, \Gamma(2m+2n)\, \Gamma(2n)\, \Gamma(m-k+\frac{1}{2}+n)\, \Gamma(n+m+k-3/2)}$$

$$(x \to 0) \quad (n=2, 3, \ldots)$$

This completes the proof of the lemma.

Lemma 7.1a When $k+m=\frac{1}{2}$ we have (Widder 1941, p. 347)

If $\int_0^\infty (x+t)^{-1}\, d\alpha(t)$ converges, then

$$\frac{\Gamma(2n)\, x^n}{\Gamma(n+1)\, \Gamma(n-1)} \int_0^\infty \frac{t^{n-1}\, \alpha(t)\, dt}{(x+t)^{2n}} \sim \alpha(0+) \frac{(n-1)}{n} \qquad (x \to 0+, n=2, 3, \ldots)$$

Lemma 7.1b When $k-m=\frac{1}{2}$, $2m+1=\rho$ we have

If $\int_0^\infty (x+t)^{-\rho}\, d\alpha(t)$ converges then

$$\frac{\Gamma(2n+\rho-1)\, x^{n+\rho-1}}{\Gamma(n+1)\, \Gamma(n+\rho-2)} \int_0^\infty \frac{t^{n-1}\, \alpha(t)\, dt}{(x+t)^{2n+\rho-1}} \sim \alpha(0+) \frac{(n+\rho-2)}{n}$$

$$(x \to 0+, n=2, 3, \ldots)$$

Theorem 7.1 If $\alpha(t)$ is a normalized function of bounded variation in $0 \leq t \leq R$ for every $R>0$ and if the integral (7.1) converges then

(7.4) $$\lim_{n \to \infty} \int_{0+}^{t} L_{n,x}\, f(x)\, dx = \alpha(t) - \alpha(0+)$$

Proof We have

$$L_{n,x}\, f(x) = d_n \int_0^\infty y^n x^{-n-1} F(2m+2n, 2n, m-k+\tfrac{1}{2}+2n, -y/x)\, d\alpha(y)$$

$$= d_n \Big[y^n x^{-n-1} F(2m+2n, 2n, m-k+\tfrac{1}{2}+2n, -y/x)\, \alpha(y) \Big]_0^\infty -$$

$$-d_n \int_0^\infty \alpha(y)\, (\partial/\partial y) \Big[y^n x^{-n-1} F(2m+2n, 2n, m-k+\tfrac{1}{2}+2n, -y/x) \Big] dy$$

$$= -d_n \int_0^\infty \alpha(y)\, (\partial/\partial y) \Big[y^n x^{-n-1} F(2m+2n, 2n, m-k+\tfrac{1}{2}+2n, -y/x) \Big] dy$$

since $\alpha(0)=0$ and $\alpha(t)=o(t)$ or $=o\left(t^{2m+1}\right)$ $(t \to \infty)$ under conditions stated in (7.3a) or (7.3b) and also (Erdélyi 1953, p.63)

$$F(2m+2n,\ 2n\ \ m-k+\tfrac{1}{2}+2n\ -y/x) \sim A_1\ \ y^{-2m-2n} + A_2\ \ y^{-2n}\ (y\to\infty)$$

if $2m$ is not zero or a positive integer

$$F(2m+2n,\ 2n;\ m-k+\tfrac{1}{2}+2n\ -y/x) \sim A_3\, y^{-2m-2n}\ \log\ y + A_4\ \ y^{-2m-2n} + A_5\, y^{-2n} \qquad (y\to\infty)$$

if $2m$ is zero or a positive integer and $m-k+\frac{1}{2} \neq 0$ or a positive integer the last term being zero when $2m=0$ and

$$F(2m+2n,\ 2n\ \ m-k+\tfrac{1}{2}+2n\ -y/x) \sim A_6\, y^{k-m-2n-\frac{1}{2}} + A_7\, y^{-2m-2n}\log y + A_8\, y^{-2n} \qquad (y\to\infty)$$

if $2m$ is zero or a positive integer and $-m-k+\frac{1}{2}$ is zero or a positive integer the second and third terms being zero when $-m-k+\frac{1}{2}=0$ or $2m=0$ (All As are constants.)

Thus in each case the integrated part vanishes.

By Euler's theorem on homogeneous functions we have

$$(\partial/\partial y)\left[\, y^{n}\ x^{-n-1}\ F(2m+2n\ \ 2n\ \ m-k+\tfrac{1}{2}+2n\ -y/x)\right] =$$

$$= (-1)\,(\partial/\partial x)\left[\, y^{n-1}\ x^{-n}\ F(2m+2n\ \ 2n;\ m-k+\tfrac{1}{2}+2n\ -y/x)\ \right]$$

Therefore

$$L_{n,m}\ f(x) = d_n\ (\partial/\partial x)\int_0^{\infty} a(y)\ y^{n-1}\ x^{-n}\ F(2m+2n,\ 2n\ \ m-k+\tfrac{1}{2}+2n\ \ -y/x)\,dy$$

If $0 < \ \ < t$ we have

$$\int_{\epsilon}^{t} L_{n,m}\ f(x)\,dx = d_n\int^{t}(\partial/\partial x)\left[\int_0^{\infty} y^{n-1}\ x^{-n}\ F(2m+2n,\ 2n;\ m-k+\tfrac{1}{2}+2n;-y/x)\ a(y)\,dy\right]dx.$$

$$= d_n\int_0^{\infty} y^{n-1}\ t^{-n}\ F(2m+2n\ \ 2n;\ m-k+\tfrac{1}{2}+2n\ -y/t)\ a(y)\ dy -$$

$$- d_n\int_0^{\infty} y^{n-1}\ \ {}^{-n}\ F\,(2m+2n\ \ 2n;\ m-k+\tfrac{1}{2}+2n\ \ -y/\epsilon)\ a(y)\ dy$$

If ϵ approaches zero then by Lemma 7 1 we have

$$\int_{0+}^{t} L_{n,m}\, f(x)\ \ dx = d_n\int_0^{\infty} y^{n-1}\ \ t^{-n}\ \ F(2m+2n\ \ 2n\ \ m-k+\tfrac{1}{2}+2n;$$

$$-y/t)\ a\,(y)\ dy$$

$$-a(0+)\,\frac{\Gamma(\ )\ \ \Gamma(2m+\ )\ \ \Gamma(m-k+\frac{1}{2}+2n)\ \ \Gamma(2n+m+k+\frac{1}{2})}{n\ \Gamma(2m+2n)\ \Gamma(2n)\ \ \Gamma(m-k+\frac{1}{2}+n)\ \ \Gamma(n+m+k-3/2)}$$

Hence if $a(y)/y \to \phi(y)$ we have by the use of Theorem 6 1 and the result (6.9)

$$\lim_{n\to\infty} \int_{0+}^{t} L_{n,n}\ f(x)\ dx = t\,\phi\,(t) - a\ (0+)$$
$$= a\ (t) - a\ (0+)$$

and the theorem is established

Corollary 7 1a. When $k+m=\frac{1}{2}$ we have the theorem due to Widder (Widder 1941 p. 348)

Corollary 7 1b When $k-m=\frac{1}{2}$ $2m+1=\rho$ we have.

If $a\ (t)$ is a normalized function of bounded variation in $0 \leq t \leq R$ for every positive R and if the integral

$$\theta\ (x) = \int_{0+}^{\infty} (x+t)^{-\rho}\ d\,a\ (t)$$

converges, then

(7 5) $$\lim_{n\to\infty} \int_{0+}^{t} L_{\ ,n}\ \theta(x)\ dx = a\ (t) - a\ (0+)$$

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Zizyphus mauritiana Lamk, popularly known as Jujube, is one of the most common fruit trees in India and is found to a considerable extent. It is commercially grown in U P., Bihar and South India The very fact that it is so widely cultivated, is, in itself, evidence that this fruit meets with relatively high degree of consumer acceptance. The observations recorded at Botanical Garden, Government Agricultural College, Kanpur (2) and reports from South India (4) show that though the tree grows well the yield is low This may be due to poor fruit setting and heavy fruit-drop The cause may be the lack of fertilization ovule sterility lack of pollen viability slow growth of pollen tubes' or its early degeneration Therefore, it was considered desirable to study in detail the floral biology of two varieties of jujube, Karaka and Small round, with a view to having a better understanding of the factors con tributing to low fruit-set and yield. This information will also be helpful in the breeding work of this fruit crop

In autumn, branchlets develop from the nodes of the old branches. They grow and develop leaves and flowers simultaneously Each leaf-axil gives rise to the flower clustur wh ch contains about 10 to 75 flowers. The flowers near the base are usually the first to mature and there is a progression toward later blossoming along the branchlet to the apex. The central flower of the cluster is the first to open while those around the edge may open as much as two weeks later As a consequence, most jujubes like Z rotundifolia have a very long blossoming period. However the species of Z mauritiana finishes flowering in a short time Flowering for fruit setting begins about the middle f September in sub-tropical conditions, and usually reaches its peak three to four weeks later but sporadic flowering may continu on some plants until middle of November

The short staked, light greenish flowers are about 2/11 to 3/11 inch in diameter Each flower consists of 5 triangular sepals 5 petals and 5 sheath enclosed stamens attached at the base to a yellowish disk. The 2 3 celled ovary sunk in the disk, terminates in 2 to 5 tyles. The ovary develops into a drupaceous fruit with a single stone

Anthesis—Anthesis in jujube takes place very fast. The floral buds re greenish white, in colour before they open. In general t was observed that the calyx separated from each other at the pex and formed a cup like shape. Soon after they turned outward exposing the stamens and pistil The pattern of anthesis is the same in Karaka and small round, both the varieties under study After full opening the flower remains in an open condition for about two days till it drops or sheds ts accessory organs.

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To determine the time of anthesis, the uniform branches were tagged and the number of flowers which opened between 4 a. m. to 9 a. m. and 11 a. m. to 4 p. m. was recorded at hourly intervals in the varieties Karaka and Small round respectively. The opened flowers were removed after every observation to avoid confusion in counting. The data regarding anthesis in Karaka are presented in Table 1 and that for Small round in Table 2.

Observations

Table 1

Time of opening of flowers in variety Karaka

Date of Observation	Percentage of flowers opened at hours					Total No. of flowers recorded	Temperature F°		Relative humidity %
	4-5 A.M.	5-6 A.M.	6-7 A.M.	7-8 A.M.	8-9 A.M.		Maximum	Minimum	
8-10-62		5 2	75 0	19 8	...	122	90 1	61 3	29
9-10-62		3 8	76 4	17 8		136	90 3	60 7	32
10-10-62		0 0	78 6	13 4		148	90 5	60 3	45
11-10-62		8 7	78 5	12 8		126	89 8	62 1	47
12-10-62		7 5	74 1	18 4		1 1	89·6	61 9	40
13-10-62		7 0	76 8	16 2		120	89 4	60 9	40
14-10-62		8 6	79 4	13 0		118	89·4	61 9	39
15-10-62		10 1	82 3	7 6		133	90 1	62 3	27

Table 2

Time of opening of flowers in variety Small round

Date of Observation	Percentage of flowers opened at hours					Total No. of flowers recorded	Temperature F°		Relative humidity %
	10-11 A.M.	11-12 A.M.	12-1 P.M.	1-2 P.M.	2-3 P.M.		Maximum	Minimum	
15-10-62		9 7	63 7	23 6		158	90·1	62 3	27
16-10-62		13 6	69 5	18 9		148	90 1	62 5	29
17-10-62		15 8	71 0	13 2		162	91 6	62 8	32
18-10-62	—	11 5	69 4	19 1	...	64	86 5	61 3	41
19-10-62	...	12 4	68 2	19 4		82	87 6	65 6	33
20-10-62		12 9	70 6	16 5		91	88 0	63 9	32
21-10-62		13 6	72 8	13 6		140	89 8	61 3	38
22-10-62		10 3	72 5	17 0		132	89 4	67 3	43
23-10-62	—	9 7	75 6	14 7	..	126	88·0	61 3	41
24-10-62	—	7 4	74 5	18 1		119	88 0	56 8	42
25-10-62		8 5	75 5	16	..	108	85 1	60·6	61

It is clear from the Table 1 that maximum number of flowers opened between 6 to 7 a. m in Karaka They began to open from 5 a m. and continued till 8 a. m. While in Small round anthesis starts at 11 a m and continued till 2 p m (Table 2) The role of temperature on the anthesis of Karaka and Small round is also clear from Table 1 and 2 respectively The percentage of flowers anthesis is also increased with the increase in temperature

Dehiscence—(a) *Mode of Dehiscence* The transverse sections of the anthers showed that there are two layers of pollen sac walls. At places where there is only one layer of cells, the endothecium ruptures from base towards top probably due to the effect of humidity and heat or internal pressure of pollen grains.

Thomas (7) stated that pollen dehiscence takes place during the first day of flower opening The observations showed that usually the anthers begin to dehisce soon after the petals open but dehiscence may begin even before the anthers emerge from their sheaths. It was also noted that the length of filaments varied from 0·3 to 0·6 cms,* ± 0·097 At the time of anthesis anthers are while in colour and two hours after the dehiscence they withered.

(b) *Time of Dehiscence* It was observed that anthers generally dehisced after anthesis This was confirmed by the following observation

The flower buds were collected an hour before anthesis. The stigmas of flower buds were stained with Lactophenol and examined under the microscope for the presence of pollen grains on it.

Pollen studies I : (a) General appearance and shape of the pollen—Pollen grains appeared as a fine whitish powdery mass, when seen with the naked eye. They remained in the anthers unless they were disturbed They were stained in methyl green glycerine jelly (8)

The pollen grains are generally of uniform size and triangular in shape, but some of them appeared deformed—compressed from one side, shrivelled and twisted. However the normal pollen grain looks almost triangular (Fig 1) The exine is fairly thick, transparent except for very slight irregular ridges. Normal pollen grains are provided with three deep sutures in exine which extended its entire length. The original shape of pollen was retained when it was stained with anilin-oil Gentian Violet. Each pollen was provided with three germpores.

(b) *Pollen size in different media*—Pollen size, in these two varieties did not vary greatly within the same medium. Observations on the size were taken in different media. The average size of 95 pollen grains was measured during the peak period of flowering and is presented in Table 3

*S.E. (Standard Error)

TABLE 3

Size of pollen grains in different media

Varieties	Aniline oil Gentian-Violet (μ)	Acetocarmine with Glycerine (μ)	Methyl green glycerine jelly (μ)	Water (μ)
Small Round	29 70	26 54	25 79	28 68
Karaka	30 56	27 42	26 51	30 17

(c) *Pollen Viability*—The viability of pollen grains was studied in acetocarmine and on stigmas of different ages. Deeply stained pollen grains with full cytoplasm were taken as viable while shrivelled and un-stained pollen were counted as non-viable They were counted in 40 random fields on the slides and the data are presented in Table 4

TABLE 4

Pollen Viability in different varieties

Varieties	Total number of pollen studied	Number of viable pollen	Number of unviable pollen	Percentage of viable pollen
Small Round	1142	936	206	81 90
Karaka	1168	1003	164	85 96

From the Table 4 it is clear that 81 98 % and 85·96 pollen grain are viable in Small Round and Karaka respectively

(d *Artificial germination of pollen grains*—Pollen grains are monosiphonous The germination of pollen was studied in different concentrations of sucrose solutions and the results are given in Table 5

TABLE 5

Germination of pollen grains in sucrose solution

Variety	Germination per cent in sucrose solutions of						
	5	10%	15%	20%	25%	30%	35%
Small Round	11 80	14 5.	23 78	33 81	51 36	81 00	32 43
Karaka	12 55	16 32	24 00	38 16	53 45	83 28	51 92

About 100 to 210 pollen grains were examined in each concentration.

Pollen studies II (*a*) *Receptivity of stigma*—The stigma was considered to be receptive when it appeared shiny and non-receptive when it looked dull in colour Controlled pollination was done on flowers which were emasculated eight hours before anthesis to 16 hours after anthesis and bagged. Further hand pollination was not done because the stigmas started drying after 16 hours of anthesis. 35 flowers were pollinated under each treatment Utmost care was taken in all the operations selection of flower buds, emasculation, pollination bagging and labelling etc.

The stigmas of emasculated flowers were pollinated with pollen from freshly dehisced anthers Out of the bagged and pollinated flowers a few stigmas were randomly taken and studied under the microscope after necessary maceration treatment To determine the percentage of pollen germination on stigma, they were fixed at various intervals after hand pollination *i* 8 16 24 32 and 40 hours.

The stigmas, for examination of pollen tube growth, were fixed in acetic alcohol (1 3) for 10 minutes. They were then preserved in 70% alcohol in order to prevent hardening until they could be examined. The following process was adopted for staining and maceration The styles previously fixed in aceto-alcohol (1 3) were stained with lactophenol after maceration (5)

(b) *Duration of Receptivity of stigma*—For receptivity the stigmas were examined with the help of hand lens (X 10) It was observed that it becomes somewhat receptive four hours prior to anthesis and maintains its receptivity upto 12 hours after the anthesis. After this period, the stigmas became dull, greenish white and the styles began to dry up and eventually the flowers dropped off if fertilization had not taken place. This was confirmed by the study of controlled pollination of emasculated flowers. Results are summarised in Table 6.

TABLE 6

Receptivity of stigma in different varieties

Varieties	Before anthesis				At anthesis		After anthesis							
	8 hours		4 hours				4 hours		8 hours		12 hours		16 hours	
		b		b		b		b		b		b		b
Small Round	50	0	50	42	50	86	50	54	50	16	50	3	50	0
Karaka	50	0	50	31	50	78	50	41	50	11	50	1	50	0

=number of flowers pollinated
b =Percentage of fruit set

(c) *Germination of pollen on the stigmatic surface*—In order to find out the correlation between the receptivity of stigma and the extent of Pollen germination and tube growth on stigmatic surface controlled pollination of emasculated flowers buds was carried out in the Karaka variety at different stigmatal ages. Then pollinated flowers were taken every time at the different intervals *i e* 4 8, 12 and 16 hours after pollination in each case The stigmas were examined for pollen germination as per method described above (5) The observations are presented in Table 7

TABLE 7

Pollen germination on stigma in variety Karaka

Sl. No.	Stigmatal age in relation to anthesis	Stigma examined after hours of pollination												Stigmatal Receptivity		
		4 hours			8 hours			12 hours			16 hours			Total stigma studied	Stigma with pollen tube	Receptivity stigma (%)
		a	b	c	a	b	c	a	b	c	a	b	c			
1	8 hours before	8	0	0	8	0	0	8	0	0	8	0	0	3.	0	0
2	4 hours before	3	3	0	4	4	0	3	3	2	3	3	2	32	17	53 13
3	At anthesis	3	4	1	0	6	3	0	2	6	0	1	7	32	29	78 13
4	4 hours after	3	2	1	2	4	2	3	4	1	4	4	0	32	18	56 25
5	8 hours after	7	1	0	7	1	0	8	0	0	6	2	0	32	4	12 5
6	12 hours after	8	0	0	7	1	0	8	0	0	8	0	0	32	1	3 13
7	16 hours after	8	0	0	8	0	0	8	0	0	8	0	0	32	0	0

a=No germination of pollen
b=Fair germination of pollen
c=Good germination of pollen

A perusal of the table indicates that the stigma had maximum receptivity at the time of anthesis but it decreased after the opening of the flower At the time of anthesis the pollen germination was 78 13 per cent while 4 hours prior to and 4 hours after anthesis it was 53 13 and 56 25 per cent respectively

DISCUSSION

Investigation on blossoming period, anthesis dehiscence and other aspects of floral biology of jujube were conducted and many interesting findings have been obtained which would offer information of importance to a breeder and also to the practical horticulturist so as to modify the cultural operations to get maximum yield In the present studies, it was observed that anthesis in Karaka variety started early in the morning and maximum percentage of

flowers opened between 6 a. m. to 7 a m. However in small round variety maximum percentage of flowers opened between 12 noon to 1 p. m. The interesting thing is the non-coincidence of anthesis in these two varieties. Similar findings have been reported by Sen *et al* (6) in mango (*Mangifera indica* L.)

Dehiscence was found to be a continuous process in both the varieties It required two to four hours to complete. As stated above, anthesis time was different in these varieties and it was affected by the temperature. It was observed that time of dehiscence also varied with the variety and is, perhaps, indirectly affected by the temperature and humidity

The pollen shape, size and viability were found to be more or less the same in both the varieties. The size of pollen grains was found to vary from 25·79 to 30 56μ in different media. Studies on pollen viability revealed that it was higher (85·96 per cent) in Karaka variety than Small round (81·98 per cent) Artificial pollen germination revealed that maximum germination was found in 30 per cent sucrose solution Prasad (2 3) also reported the maximum pollen germination and tube growth in 30 per cent sucrose medium. However Addicot (1) reports that pollen germination and tube growth are two different processes which depend upon the physiological conditions of the pollen grain at the time of testing

Studies on receptivity of stigma in jujube lead to the conclusion that it has maximum receptivity at the time of anthesis and it continues to be re ceptive even after 12 hours of opening of the flower

SUMMARY

1 Detailed floral biological studies were conducted in two jujube varieties namely Karaka and Small Round in the year 1962.

2. Time of anthesis varied in both the varieties and the anthesis is completed in a very short time. Temperature had an influence on the time and intensity of anthesis.

3 Dehiscence takes place from anthesis to 4 hours after opening of the flower

4 In the two varieties studied, the pollen grains were almost simila in shape however the size of the pollen grains in aniline oil Gentian violet was 30·56 $\mu \pm$ 0 12 in Karaka and 29 70 $\mu \pm$ 0·16 in Small Round variety Pollen grains of both the varieties were h ghly viable.

5 Maximum artificial pollen germination was recorded in 30 per cent sucrose solution

6 Stigma becomes receptive four hours prior to anthesis and recepti- vity remained at peak at the time of anthesis and continued upto 12 hours after anthesis

(c) *Germination of pollen on the stigmatic surface*—In order to find out the correlation between the receptivity of stigma and the extent of Pollen germination and tube growth on stigmatic surface, controlled pollination of emasculated flowers buds was carried out in the Karaka variety at different stigmatal ages. Then pollinated flowers were taken every time at the different intervals i e 4 8 12 and 16 hours after pollination in each case The stigmas were examined for pollen germination as per method described above (5) The observations are presented in Table 7

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		a	b	c	a	b	c	a	b	c	a	b	c			
1	8 hours before	8	0	0	8	0	0	8	0	0	8	0	0	32	0	0
2	4 hours before	5	3	0	4	4	0	3	3	2	3	3	2	32	17	53 13
3	At anthesis	3	4	1	0	6	3	0	2	6	0	1	7	32	29	78 13
4	4 hours after	5	2	1	2	4	2	3	4	1	4	4	0	32	18	56 25
5	8 hours afte		3	0	7	1	0	8	0	0	6	2	0	32	4	12 5
6	12 hours after	8	0	0	7	1	0	8	0	0	8	0	0	32	1	3 13
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DISCUSSION

Investigation on blossoming period anthesis, dehiscence and other aspects of floral biology of ber (jujube) were conducted and many interesting findings have been obtained which would offer information of importance to a breeder and also to the practical horticulturist so as to modify the cultural operations to get maximum yield In the present studies, it was observed that anthesis in Karaka variety started early in the morning and maximum percentage of

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2	4 hours before	5	3	0	4	4	0	3	3	2	3	3	2	32	17	53 13
3	At anthesis	3	4	1	0	8	3	0	2	6	0	1	7	32	25	78 13
4	4 hours after	5	2	1	2	4	2	3	4	1	4	4	0	32	18	56 25
5	8 hours after	7	1	0	7	1	0	8	0	0	6	2	0	32	4	12 5
6	12 hours after	8	0	0	7	1	0	8	0	0	8	0	0	32	1	3 13
7	16 hours after	8	0	0	8	0	0	8	0	0	8	0	0	32	0	0

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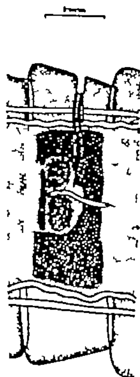
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Fig 1 Pollen gra



Fig. 1





ANOTHER METHOD FOR THE DETERMINATION OF POTASSIUM DICHROMATE AND POTASSIUM PERMANGANATE IN A MIXTURE

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Vaish and Prasad[1] have found that the amounts of $KMnO_4$ and $K_2Cr_2O_7$ can be accurately determined in a mixture of the two by the following volumetric method —

At first a known volume of the mixture is titrated against a standard solution of ferrous ammonium sulphate, using potassium ferricyanide as an external indicator. Then a second lot of the same volume of the mixture, made alkaline by adding a slight excess of solid Na_2CO_3, is treated with slight excess of a solution of H_2O_2 until all the permanganate is precipitated as hydrated manganese dioxide and the supernatant solution is distinctly yellow. The precipitate is then filtered off and washed on the filter paper with warm water; the collected filtrate is boiled to remove the excess of H_2O_2, cooled, acidified with dilute H_2SO_4 and titrated against the same solution of ferrous ammonium sulphate.

The values found in two titrations are used to calculate the amounts of $KMnO_4$ and $K_2Cr_2O_7$ in the given mixture. They have also found that the accuracy of the method is not affected by the change of the proportion of $KMnO_4$ and $K_2Cr_2O_7$ in the mixture.

The author has employed a modified method for this determination by avoiding the use of the external indicator. The amounts of total $KMnO_4$ and $K_2Cr_2O_7$ and of $K_2Cr_2O_7$ alone, obtained by the method of separation used by Vaish and Prasad, in a given volume of the mixture of the two were determined as follows —

25 ml. of the mixture or the solution obtained after the separation of $KMnO_4$ from the same volume, were added to a mixture containing 5 ml. of 60% solution of KI and 25 ml. of 10% solution of $NaHCO_3$ in 100 ml. of CO_2 free distilled water to which 6 ml of concentrated HCl or its equivalent of H_2SO_4 were slowly added with gentle rotation of the container. The liberated iodine was titrated against the standard solution of $Na_2S_2O_3$, the end point being indicated by starch.

Following solutions were used in the investigation: (1) $KMnO_4$—0.1 N (2) $K_2Cr_2O_7$—0.100185 N (3) KI—60%, (4) $NaHCO_3$—10% (5) $Na_2S_2O_3$—N/21.6, (6) CO_2 free water (7) Na_2CO_3—4.0 N (8) H_2O_2—nearly 4.0 N (9) HCl—concentrated. All solutions were prepared from A. R. chemicals in distilled water. An approximate solution of (5) was made and after

keeping it over-night its correct strength was determined by titration against 0·1 N $CuSO_4$. Strengths of (1) and (2) were determined by titrating against (5) and of (8) by titrating against (1).

The results obtained with mixtures containing different proportions of $KMnO_4$ and $K_2Cr_2O_7$ are given in the following table.

TABLE

ml. of $K_2Cr_2O_7$ in mixture	25	20	15	10	5	0
ml. of $KMnO_4$ in mixture	0	5	10	15	20	25
%age of $K_2Cr_2O_7$ in mixture	100	80	60	40	20	0
ml. of $Na_2S_2O_3$ for mixture (found)	54·10	54·10	54·10	54·08	54·05	54·00
ml. of $Na_2S_2O_3$ for mixture (expected)	54·10	54·08	54·06	54·04	54·02	54·00
ml. of $Na_2S_2O_3$ for $K_2Cr_2O_7$ alone (found)	54·10	43·30	32·50	21·70	10·85	0
ml. of $Na_2S_2O_3$ for $K_2Cr_2O_7$ alone (expected)	54·10	43·28	32·46	21·64	10·82	0

It will be seen from the above table that the method adopted in this investigation leads to accurate determination of the amounts of $KMnO_4$ and $K_2Cr_2O_7$ in a mixture containing the two substances in any proportion without having to use an external indicator.

Instead of the external indicator diphenylamine can be used as the internal indicator in Vaish and Prasad's method, but the accuracy of estimations may not be high as the change of colour at the end point from blue to green may not be sharply noticed by an unpractised worker.

I am grateful to Dr. Mata Prasad, D.Sc., F.R.I.C., F.N.I., for suggesting the problem and to Dr. P. I. Ittyerah Ph. D., A.R.I.C., for giving facilities for doing this work.

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INFLUENCE OF STEM-GALL DISEASE ON FRUIT QUALITY IN CORIANDER

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INTRODUCTION

Coriander seeds (fruits) are extensively used as condiment in the pre paration of curry powder pickling spices, sausages and seasonings. They are considered as carminative, stomachic, refrigerant and diuretic, but in fected fruits become hypertrophied due to attack of *Protomyces macrosporus* Ung and appear to lose all such properties. In the present study an investigation was undertaken to assess in what respects the quality of the seeds deteriorate by the infection.

METHOD AND MATERIAL

Healthy and diseased (fully hypertrophied) seeds were collected from healthy and infected plants at maturity and were analysed in triplicates, for their chemical composition following the conventional A.O.A.C. methods (Wright 1938) The following constituents were studied (i) moisture (ii) fat (iii) protein (iv) carbohydrates (v) fibre (vi) mineral matter In addition to above analysis fractions of carbohydrates (educing and invert sugars) and proteins (total nitrogen and protein nitrogen) were estimated in duplicates. Sugars (reducing and invert) and fractions of nitrogen were analysed olorimetrically following the methods suggested by Snell and Snell (1955) with the help of Photospectrometer-spectronic—20

RESULTS

Chemical analysis of seeds, diseased and healthy is given in Table 1

TABLE 1

Chemical analysis of healthy and diseased seeds

(Mean of 3 reading)

Chemical constituents	% Values	
	Healthy seeds	Diseased seeds
Moisture	10·9	11 4
Protein	15 2	11 2
F t	16 3	2 6
Carbohydrates	18 9	11 5
Fibre	31 5	56 5
Mineral matter (ash)	6 4	7 0

From the data listed above, it is evident that the quality of the diseased seeds is adversely affected. Proteins fats and total carbohydrates decrease while fibre matter increases and so also the mineral matter The moisture content also increases, though very slightly

Fractions of carbohydrates are represented in Table 2

TABLE 2

Sugar constituents of healthy and diseased seeds (fruits) of coriander
(Mean of 2 values)

Seeds	Sugars	
	Reducing	Invert
Healthy	0 24%	0 66%
Diseased	Trace	0·0

In the diseased seeds the amount of reducing sugars decrease to the minimum as they are present in traces only Invert sugars, on the other hand a e absent completely

Fractions of nitrogen are gi en in Tal le 3

TABLE 3

Nitrogen const tuents f healthy and diseased frut f coriander
(Mean f 2 values)

Seeds	Nitrogen	
	Total-N	Protein-N
Healthy	4 2	2 4%
Diseased	3 7%	1 8%

Fra tions of nitrogen also indicate that Total-N and Protein N are depressed in the diseased seeds.

DISCUSSION

Before attending the discussion of the results it would be worthwhile to compare the results of the present study on the chemical composition of cori-

ander fruits obtained from the healthy fruits with the analysis given by that of Aiyer

Name of worker	Moisture	Fibre	Ash	Fat	Protein	Carbo-hydrates
Present data	10 9	31 3	6 4	16 3	15 2	19 9
Aiyer (1951)	11 2	32 6	4 4	16 1	14 1	21 6

The results of the present study agree fairly with those reported by Aiyer The small variations can be attributed to the variety of coriander under study and also to the condition of growth.

Now reverting to the comparison between healthy and diseased fruits, represented graphically in Fig 1 It is clear from the results that the diseased seeds *deteriorate completely* so far as their use as condiment is concerned. Depletion in the amount of fats, proteins, and carbohydrates is well marked. However an increase is noted in fibre and also in mineral matter to a considerable extent. This increase in fibre and ash (mineral matter) seems mainly due to chlamydospores because the tissue of the diseased fruits do not show any fibrous thickening whatsoever as revealed by a study of the pathological anatomy (Gupta, 1962) Examination of fractions of sugars and nitrogen (Fig 2) reveals a great decrease in reducing sugars while invert sugars are completely absent. Chromatographic analysis of the deseased fruits by Gupta & Gupta (1962) exhibited the presence of glucose alone, while fructose, raffinose and sucrose present in healthy seeds were deplected completely Similar reduction in protein-N and Total-N is also seen in diseased seeds. The presence of millions of chlamydospores of the pathogen in the diseased seeds (fruits) may not exhibit a true picture of the changes occurred therein, yet it is evident that the infected seeds are adversely affected. The diseased seeds *lose their characteristic smell* and cannot be used as condiment.

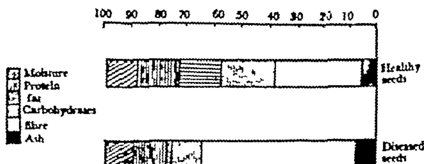
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The author expresses his deep sense of gratidute to Professor S. Sinha for guidance and helpful criticism during the progress of this investigation

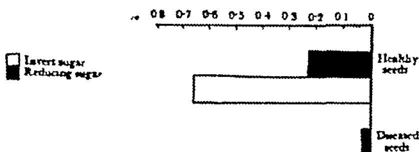
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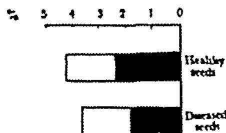
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Fig 1


100 90 80 70 60 50 40 30 20 10 0
Healthy seeds
Diseased seeds
Moisture
Protein
fat
Carbohydrates
fibre
Ash

Fig


0·8 0·7 0·6 0·5 0·4 0·3 0·2 0·1 0
Invert sugar
Reducing sugar
Healthy seeds
Diseased seeds


%
5 4 3 2 1 0
Healthy seeds
Diseased seeds
Protein-N

STUDIES ON THE ECOLOGY AND POPULATION PATTERN OF *OECOPHYLLA SMARAGDINA* FABR (FORMICIDAE HYMENOPTERA) DURING SPRING IN HARDWAR*

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INTRODUCTION

Oecophylla smaragdina Fabr the notorious and vicious 'Red Ant' of India inhabits trees and makes a nest of leaves thereby causing extensive damage to foliage. Rothney (1889) Aitken (1889 and 1890) Wroughton 1893-94) and Green (1900) have described the habits of this ant. Green (1900) has further reported on the utilisation of larvae by the adults in the construction of nests. Hingston (1923) while dealing with the habits has discussed in some details the process of nest construction. He has also examined the microscopical structure of the nest forming material the silk. Way (1954) and Vanderplank (1960) have studied the bionomics and ecology of an allied species of *Oecophylla* in Zanzibar The economic importance of this ant has been emphasised by Aitken (1889) Bingham (1903) Groff and Howard (1924) Morley (1953) Way (1954) and Vanderplank (1960 Ecology and pattern of nest population of such an economically important ant, under the climatic conditions of India have however not been studied. In this paper are summarised the results of studies on the ecology and the population structure of *Oecophylla smaragdina* carried out at Gurukul Kangri Hardwar U P in the months of March, April and May 1962

GEOGRAPHICAL SITUATION AND CLIMATIC CONDITIONS OF HARDWAR

Hardwar is situated within th subtropical egion Lat. 29 58 N., Long 78 13 E. at an altitude of 965 feet above mean sea level and stands on the right bank of the river Ganga at the foot of the Siwalik or the foot hills of Himalaya. Winters are rather extreme but summers relatively moderate. Actual weather data recorded at Roorkee, Lat 29-51 N., Long 77 59 E. at an altitude of 887 feet above mean sea level, about 16 miles south-west of Hardwar would roughly represent the conditions at this place. The data collected during 1961 is as follows —

Average maximum temperature	43 7°C
Average minimum temperature	4.0°C
Average rainfall	49 19 inches.

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*Contribution No. 101 from th School of Entomology St John' College Agra.

Description of Locality and Station

The observations were recorded on alternate days from March 1962 onwards till about the third week of May 1962 at various spots and on nests situated on a number of trees in the campus of Gurukul Kangri two miles to the southwest of Hardwar railway station

Occurrence of Nests

Oecophylla nests in the locality under observation were found on a variety of trees *viz* *Mangifera indica* the mango *Terminalia arjuna*, the arjuna; *Pongamia glabra*, the karanja *Putranjiva roxburghii*, the jiapota and *Eugenia jambolana* the jamun. The height of the nests from the ground varies from 2 metres to 20 metres. Invariably the nests are situated on the exposed, windy southeast faces of the trees where maximum solar radiation is available. This preference for high temperature has also been observed by Allee and others (1949) in various species of ants and termites. Way (1954) has pointed out that *Oecophylla longinoda* Lat. in Zanzibar builds its nests on sunny but sheltered side of the trees where wind may not obstruct the nest building activities. Vanderplank (1960) has however remarked that in the case of *Oecophylla longinoda* it is sun and not the wind that matters. The observations under the present investigations corroborate the findings of Vanderplank.

Diel Activity

Observations recorded at different hours of the day and night during the months under observation exhibit no definite pattern of activity In March the ants are exceedingly active during the hours of sunshine while in April and May the mid-day activity on the other hand, is at its minimum. During April and May the activity is stepped up at dusk which continues throughout the night and shows a marked decline after about 9 a. m. It is clear from the above description that the diel activity is not controlled merely by the sunshine but other abiotic ecological factors like temperature and humidity also have a well pronounced effect.

Temperature and Activity

Observations recorded in relation to temperature reveal that the period of activity is confined to the temperature limits from 15°C to 35°C. Below 15 C the low temperature retards their normal activity and a rise above 35 C adversely effects their movements.

Table 1

Statement showing the average minimum and maximum temperatures (°C) during March April and May 1962 at Hardwar

Month	Minimum	Maximum
March	10 0	31·0
April	14 0	41·0
May	21 0	44·0

In March when the night temperature goes below 15.9°C the ants are inactive throughout the night. On the other hand, mid-day temperatures during April and May rise beyond 35°C resulting in etardation of activity during most of the hours of sunshine. The favourable range of temperature *i. e.* between 15 C and 35°C during April and May is available during the night, in the early hours of the morning and in late evenings. Therefore, during these months the ants are inactive during most of the day time when the high temperature is unfavourable. It is worth-while to point out here that high temperatures need not necessarily drive the ants to their nests but they may seek shelter in any shaddy spot outside the nest.

RAINFALL AND ACTIVITY

During these three months rain or clouds have not shown any marked effect upon the activity except when they have been causative agents in bringing about a very appreciable fall in temperature. It was only very rarely that heavy rains which caused the temperature to fall down below 15°C, drove the ants to their nests. With a rise of temperature to about 17°C even on cloudy and rainy days, ants could be seen active both on the ground as well as on the tree trunks.

WIND AND ACTIVITY

Observations recorded show that changes in wind velocity during these three months have no ill effect upon the activity of the ants. During the construction of the nests however the increased wind velocity does show a marked influence on the construction activities. The fierce wind scatters the material of the nest construction in consequence of which the ants abandon that material and retire. Immediately after the restoration of calm they return to their construction work.

RANGE AND DIRECTION OF MOVEMENTS

Oecophylla smaragdina exhibits a marked preference for eastern and southern directions in the choice of their territory of movement. There is a well pronounced negative reaction towards the northern and western sides of the nest bearing tree. At no time during the day an ant could be observed moving to the northern and western sides of the tree.

During March and April the ants explore a wider territory upto about 30 metres from the tree trunk, while in May the range of exploration is reduced to about 15 metres. The reduction in the range of activity seems to be the result of the availability of insect food nearer at hand during the hot month of May when the trees bear fresh foliage and inflorescence that attract various kinds of insects fed upon by ants. In addition, the higher temperat ure is also responsible for restricting the zone of activity

Feeding Habits

Aitken (1889) Wroughton (1893-94) and Hingston (1923) while describing the predatory and carnivorous habits of this ant have mentioned that the ants can attack and devour insects, bigger reptiles and mammals. The author has seen dead *Camponotus* (Formicidae Hymenoptera) soldiers and workers being driven by *Oecophylla* workers towards their nests Experimentally living *Camponotus* and *Dysdercus cingulatus* (Pyrrhocoridae Heteroptera) individuals were strewn in the territory of *Oecophylla* which were instantaneously captured and removed by the workers of the latter to their nest. Besides, the honey dew secreted by aphids and Membracid bugs (cow bugs) is extensively utilised.

Nest Population

The data reproduced below gives an idea about the population structure of the two nests collected in March and April respectively The nests after having been taken off from the trees were placed in glass jars and chloroformed The volume of the March nest was calculated mathematically as its shape was somewhat conical but that of the April nest was estimated by sand displacement method because of its irregular shape Population numbers have been estimated by direct counts.

TABLE 2

Statement showing collection data and other ecological conditions of the nests of Oecophylla smaragdina

Serial No.		March nest	April nest
1	Date of collection	11 3-62	22-4-62
	Time of collection	6 45 a m	5 30 a m
3	Air temperatur	11°C	22°C
4	Atmospheric pressure	29 01 inches	29 00 inches
5	Humidity	92%	78%
6	Wind	North-east mild wind	North-east mild wind
7	Sky	Clear	Clear
8	Tree from which the nest was collected	*Terminalia Arjuna*	*Mangifera indic*
9	Height of the nest from the ground	7 metres	4 metres
10	Shape of the nest	Conical	Irregular
11	Weight of the nest	220 grams	128 5 grams
12	Volume of the nest	1648 5 cc.	800 cc

TABLE 3

Statement showing the population structure of the nests of Oecophylla smaragdina

Serial No.		March nest		April nest	
		Actual number	Percentage	Actual number	Percentage
1	Eggs	1650	5 2	Absent	...
2	Undifferentiated larvae	4015	12 64	191	5 68
3	Undifferentiated pupae	4254	13 39	115	3 42
4	Queen larvae	Absent	...	272	8 09
5	Queen pupae	Absent	...	55	1 63
6	Workers minor	7890	24 85	434	12 89
7	Workers major	13940	43 90	2293	68 24
	Total population	31249	...	3360	
	Density of population	19 25 individuals per cc.	...	4 2 individuals per cc	...

The data provided in the tables 2 and 3 reveal that though the nests were collected in the early hours of the day both in March and April, yet the population density inside the nest is much higher in the former case. This greatly pronounced difference seems to be the result of rather sub-optimal and unfavourable low temperature in March, which drives all the individuals inside the nest. On the other hand the temperature in the early hours of April, as discussed earlier is agreeable and a large number of workers remain outside the nest in persuit of their duties. Further it has been pointed out that in April though the activity is reduced at mid-day the ants do not retire to their nest but take shelter under any nearby shady situation. Thus th absence of such large numbers of individuals from the nest seem to be at the back of reduced population density in April.

From the Figure 1 and Table 3 we find that during March the population contains a considerable proportion of immature stages *i. e* eggs 5.2%, undifferentiated larvae 12.64% and undifferentiated pupae 13.39% In April all the eggs have hatched and the percentage of other immature stages has also been appreciably reduced. Most of these eggs and immature stages fter having completed their development under relatively high temperature in April, have contributed to the adult population This increase in the adult proportion at the cost of immature stages in April has resulted in a higher percentage of

workers in this month which represent about 80% of the whole nest population. This figure would have further increased had all the workers remained inside the nest

It is interest ng to point out here, that during April the queen larvae and pupae have also become differentiated and represent about 8.09% and 1.63% of the total nest population respectively

ECONOMIC IMPORTANCE

Views on the economic importance of this ant have always been conflicting and an extensive work would be required before its economic importance can correctly be evaluated. According to Wroughton (1893-94) this ant is definitely harmful to agriculture on account of its aphid rearing habits. Their habitation on trees is considered by Aitken (1899) as injurious to the interests of birds as the latter find it difficult to live on the same tree. Morley (1923) reports the destruction of only skin of the coffee plant by this ant in Ceylon. Way (1954) regards the ant as a nuisance because of its painful bites which hinder harvesting and also because it kills honey bees. Extensive infestation of the mango t ees at Gurukul Kangri was observed to impart a naked appearance to the trees because of the consumption of the foliage in nest building

Bingham (1903) has mentioned that the ant has been used as a condiment n Kanara and some other parts of India and throughout Burma and Siam. Its chief use as p inted out by Groff and Howard (1924) Morley (1953) Way (1954) and Vanderplank (1960) has been for the biological control of a number of harmful bugs caterpillars, beetles etc. In the present investigations *Oecophylla* has been observed to be predaceous upon the harmful bug *Dysdercus cingulatus* in addition to ther tending the useful lac insect.

SUMMARY

1 A brief account of the ecological conditions and the population structure of the nest of *Oecophylla smaragdina* during spring in Hardwar have been discussed.

2 It is pointed out that the range of activity of the ant is confined to the east and south of the nest.

3 The ants remain active f om 15°C to 35°C, but below and above these temperatures they become inactive and either retire to their nests or take shelter under any available shady spot.

4 Mere approach of louds or l ght d izzle do not adversely effect the activ ty of th s ant

5 Changes in the velocity of wind also fail to effect their activity

6. In April and May when the temperature is higher the ants do not venture far away f om the r nest

7 The nest population in March contains a considerable proportion of eggs and immature stages thereby reducing the percentage of adults. By April, however the immature stages and eggs complete their development and increase the adult proportion

8 The population density in April is considerably less than in March because of the wandering habits of the workers stimulated by favourable temperatures.

9 A note is also added on the economic importance of these ants.

ACKNOWLEDGEMENTS

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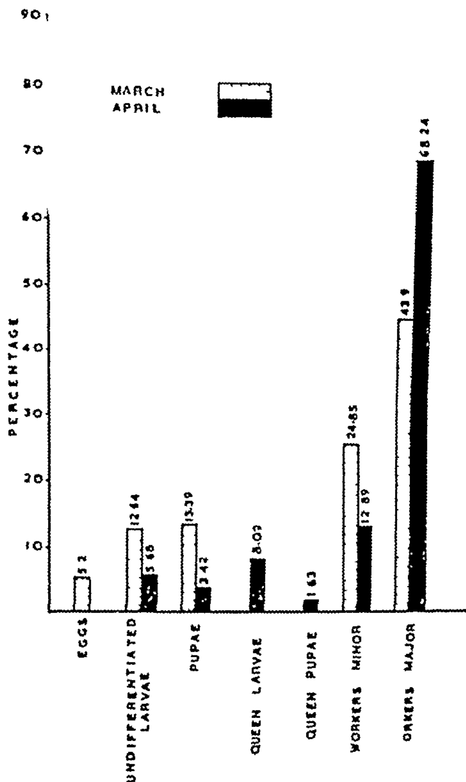


Fig 1 Histogram showing h percentage of rious omponents of the populatio structure of *Oecophylla* ... in March d April. The black columns represen April and ippled olumns represen March.

A NOTE ON AN INTEGRAL INVOLVING ULTRASPHERICAL POLYNOMIALS

S. C. Mittal

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1·0 Mitra (1935 36 39) obtained certain relations between Legendre Polynomials and Bessel functions B. N Bose (1944) and S K. Bose (1946) added some interesting results. A. Sharma (1950)) generalised some of these results by obtaining certain theorems on ultraspherical polynomials. Here an integral involving ultraspherical has been obtained.

2·0 We use the formula for $P_n^\lambda(x)$

$$P_n^\lambda(x) = \frac{(-2)\ \Gamma(n+\lambda)\ \Gamma(n+2\lambda)}{n!\ \Gamma(2n+n\lambda)\ \Gamma\lambda}(1-x^2)^{\frac{1}{2}-\lambda}\frac{d^n}{dx}\left|(1-x^2)^{n+\lambda-\frac{1}{2}}\right|$$

which is analogous to Rodrigue's Formula for $P(x)$ Obviously if $\lambda=\frac{1}{2}$ it reduces to Legendre's Polynomial of first kind.

Throughout the discussion we shall consider n to be an integer and $\lambda > -\frac{1}{2}$

3 1 **Theorem**

$$\int_0^1 P_n^\lambda(1-2y^2)(1-y^2)^{\lambda-\frac{1}{2}}y^{2\lambda}\ {}_mF_p(\alpha_1\ \alpha_2\ \ \alpha_m\ \ \beta_1, \beta_2\ \ \beta_p\ \ -y^2t^2)dy$$

$$= \frac{\sqrt{\pi}\ \Gamma(n+2\lambda\ (\alpha_1)\ \ (\alpha_2)\ \ ..(\alpha_m)\ \ \Gamma n+\lambda+\frac{1}{2}.t^{2n}}{2^{2\lambda}n!\ \Gamma\lambda\ (\beta_1)\ \ (\beta_2)\ \ \ (\beta_p)\ \ \Gamma(2n+2\lambda+1)} \times$$

$${}_{m+1}F_{p+1}\left[\begin{matrix}\alpha_1+n,\ \alpha_2+n & \alpha_m+n,\ n+\lambda+\frac{1}{2}\\ \beta_1+n,\ \beta_2+n & ..\ \beta_p+n\ \ 2n+2\lambda+1\ \ -t^2\end{matrix}\right]$$

provided $m \ngtr p+1$

Proof

$$\Sigma = \int_0^1 P_n^\lambda(1-2y^2)(1-y^2)^{\lambda-\frac{1}{2}}y^{2\lambda}\ {}_mF_p(\alpha_1, \alpha_2\ \ \ \alpha_m; \beta_1\ \beta_2\ \ \beta_p; -y^2t^2)\ dy$$

$$= \int_0^1 P_n^\lambda(1-2y^2)(1-y^2)^{\lambda-\frac{1}{2}}y^{2\lambda}\ \sum_{r=0}^{\infty}\frac{(-1)\ (\alpha_1)_r\ \ (\alpha_m)\ \ (y\ )^{2r}}{(\beta_1)_r\ \ (\beta_p)_r\ r!}\ dy$$

where $(\alpha) = \Gamma\alpha+r \mid \Gamma\alpha$

now using the formula

$$\int_0^1 P_n^{\lambda}(1-2y^2)(1-y^2)^{\lambda-\frac{1}{2}} y^{2\lambda+2r+2\nu}\, dy$$

$$= \frac{\sqrt{\pi}(-1)^n \Gamma(n+2\lambda)\Gamma(\nu+r+1)\Gamma(\nu+r+\lambda+\frac{1}{2})}{2^{2\lambda} n!\,\Gamma\lambda\,\Gamma(\nu+r+1-n)\Gamma(\nu+r+n+2\lambda+1)} \quad (1)$$

$(\lambda+r+\nu) > -\frac{1}{2}$ n a positive integer and $\lambda > -\frac{1}{2}$ (Sharma, 1951)
we have

$$I = \sum_{r=0}^{\infty} \frac{\sqrt{\pi}(-1)^n \Gamma(n+2\lambda)\Gamma(r+1)\Gamma(r+\lambda+\frac{1}{2})(-1)^r (a_1)_r \ldots (a_m)_r z^{2r}}{2^{2\lambda} n!\,\Gamma\lambda\,\Gamma(r-n+1)\Gamma(r+n+2\lambda+1)(\beta_1)_r \ldots (\beta_p)_r r!}$$

now since terms for $r=0, 1, \ldots (n-1)$ vanish, we have

$$I = \sqrt{\pi} \sum_{R=0}^{\infty} \frac{(-1)^R \Gamma(n+2\lambda)\Gamma(n+R+1)\Gamma(n+R+\frac{1}{2}+\lambda)}{2^{2\lambda}\Gamma\lambda\, n!\,\Gamma(R+1)\Gamma(2n+2\lambda+R+1)} \frac{(a_1)_{n+R} \ldots (a_m)_{n+r} (z)^{2n+2R}}{(\beta_1)_{n+R} \ldots (\beta_p)_{n+R} \times (n+R)!}$$

$$= \sqrt{\pi} \frac{\Gamma(n+2\lambda)(a_1) \ldots (a_m)\Gamma(n+\lambda+\frac{1}{2})(z)^{2n}}{2^{2\lambda} n!\,\Gamma\lambda(\beta_1) \ldots (\beta_p)\Gamma(2n+2\lambda+1)} \times$$

$$\left[1 - \frac{(a_1+n)(a_2+n) \ldots (a_m+n)(n+\lambda+\frac{1}{2})}{(\beta_1+n)(\beta_2+n) \ldots (\beta_p+n)(2n+2\lambda+1)} z^2 + \ldots\right]$$

$$= \frac{\sqrt{\pi}\,\Gamma(n+2\lambda)(a_1)_n \ldots (a_m)_n \Gamma(n+\lambda+\frac{1}{2})(z)^{2n}}{2^{2\lambda} n!\,\Gamma\lambda(\beta_1)_n \ldots (\beta_p)_n \Gamma(2n+2\lambda+1)} \times$$

$${}_{m+1}F_{p+1}\left[\begin{matrix} a_1+n, a_2+n \ldots (a_m+n)\ (n+\lambda+\frac{1}{2}) \\ (\beta_1+n), \ldots (\beta_p+n)\ (2n+2\lambda+1) \end{matrix}; -z^2\right]$$

provided $m \ngtr p+1$

3.2 *Special case of the theorem.*

Putting $m=2, p=1$ and taking $a_1=-\mu$
$a_2=\mu+\frac{1}{2}$, $\beta_1=\frac{1}{2}$ where μ is an integer greater than n, we have

$$I_1 = \int_0^1 P_n^{\lambda}(1-2y^2)(1-y^2)^{\lambda-\frac{1}{2}} y^{2\lambda} {}_2F_1(-\mu, \mu+\tfrac{1}{2}; \tfrac{1}{2}; -y^2z^2)\, dy$$

$$= \frac{\sqrt{\pi}\,\Gamma(n+2\lambda)(-\mu)_n(\mu+\frac{1}{2})_n \Gamma(n+\lambda+\frac{1}{2}) z^{2n}}{2^{2\lambda} n!\,\Gamma\lambda\,(\frac{1}{2})_n \Gamma(2n+2\lambda+1)}$$

$${}_3F_2\left[\begin{matrix} -\mu+n, \mu+n+\frac{1}{2}, n+\lambda+\frac{1}{2} \\ \frac{1}{2}+n, (2n+2\lambda+1) \end{matrix}; -z^2\right]$$

$$\text{or } I_1 = \int_0^1 P_n^{\lambda}(1-2y^2)(1-y^2)^{\lambda-\frac{1}{2}} y^{2\lambda} \frac{(-1)^{\mu} 2\mu!}{2^{2\mu}(\mu!)^2}\, {}_2F_1[-\mu, \mu+\tfrac{1}{2}; \tfrac{1}{2}; y^2(iz)^2]$$

$$= \frac{\sqrt{\pi}\,\Gamma(n+2\lambda)\,(-\mu)_n\,(\mu+\tfrac{1}{2})_n\,\Gamma(n+\lambda+\tfrac{1}{2})\,(-1)^{\mu}\,(2\mu)!\,(iz)^{2n}}{i^{2n}\,2^{2\lambda+2\mu}(\mu!)^2\,n!\,\Gamma\lambda\,(\tfrac{1}{2})_n\,\Gamma(2n+2\lambda+1)} \times$$

$${}_3F_3\left[-\mu+n,\ \mu+n+\tfrac{1}{2},\ n+\lambda+\tfrac{1}{2};\ \tfrac{1}{2}+n,\ 2n+2\lambda+1;\ (iz)^2\right]$$

$$\text{or} \int_0^1 P_n^{\lambda}(1-2\lambda t^2)\,(1-y^2)^{\lambda-\frac{1}{2}}\,y^{2\lambda}\,\frac{(-1)^{\mu}2\mu!}{2^{2\mu}(\mu!)^2}\,{}_2F_1\left(-\mu,\ \mu+\tfrac{1}{2};\ \tfrac{1}{2};\ y^2t^2\right)dy$$

$$= \frac{\sqrt{\pi}\,\Gamma(n+2\lambda)\,(-\mu)_n\,(\mu+\tfrac{1}{2})_n\,\Gamma(n+\lambda+\tfrac{1}{2})\,(-1)^{\mu+n}\,2\mu!\,t^{2n}}{2^{2\lambda+2\mu}(\mu!)^2\,n!\,\Gamma\lambda\,(\tfrac{1}{2})_n\,\Gamma(2n+2\lambda+1)} \times$$

$${}_3F_3\left(-\mu+n,\ \mu+n+\tfrac{1}{2},\ n+\lambda+\tfrac{1}{2};\ \tfrac{1}{2}+n,\ 2n+2\lambda+1;\ t^2\right)$$

Replacing $\frac{(-1)^{\mu}\,2\mu!}{2^{2\mu}\,(\mu!)}\ {}_2F_1\left(-\mu,\ \mu+\tfrac{1}{2};\ \tfrac{1}{2};\ (yt)^2\right)$ by $P_{2\mu}(yt)$

We have

$$\int_0^1 P^{\lambda}\,(1-2y^2)\,(1-y^2)^{\lambda-\frac{1}{2}}\,y^{2\lambda}P_{2\mu}(y\,)\,dy$$

$$= \frac{(-1)^{n+\mu}\,\Gamma(n+2\lambda)\,2\mu!\,\sqrt{\pi}\,z^{2n}(-\mu)_n\,(\mu+\tfrac{1}{2})_n\,\Gamma(n+\lambda+\tfrac{1}{2})}{2^{2(\mu+n)}\,n!\,\Gamma\lambda\,(\mu!)^2\,(\tfrac{1}{2})_n\,\Gamma(2n+2\lambda+1)} \times$$

$$F_3\left(-\mu+n,\ \mu+n+\tfrac{1}{2},\ n+\lambda+\tfrac{1}{2};\ n+\tfrac{1}{2},\ 2n+2\lambda+1;\ z^2\right)$$

where μ (an integer) $> n$

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THE EXTERNAL MORPHOLOGY OF ANAX PARTHENOPE SELYS. (AESHNIDAE, ODONATA)

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The morphology of the dragonflies has been worked out very little by the present and earlier workers. The main emphasis of the entomologists has always been on wings and thus a series of papers have been published from time to time. The present paper is an attempt to fill up the lacunae n the existing knowledge of morphology of the dragonflies. *Anax parthenope* measures 7.5 cm. and like all other insects its body is divisible into three parts *i.e.* head, thorax and abdomen.

HEAD

The head is hypognathous and globular in structure with the occipital cavity behind. The attachment with the prothorax is in such a way that the head rotates on two cervical sclerites—the occipital condyles.

The head sclerites and sutures (Pl. 1 Fig 2 & 3)—A small but well marked sclerite, the occiput, triangular in shape and of light pale colour is situated between and behind the two compound eyes, covered with minute bristles. Posteriorly the occiput forms the rim of the occiptal cavity On the vertex—the dorsal portion of cranium a narrow line separating the two eyes runs just from the posterior extremity to the nearest angle of the occiput. Due to the greater development of the eyes the vertex is somewhat puffed forwards and is covered with many small bristles.

There are three ocelli, two of them are situated just above the place of origin of each antenna, the third is the largest having a knob like structure situated in the middle of the boundary line between the vertex and the frons which is pale olivaceous. A ribbon like dark band traverses the entire breadth of the frons shield. The vertex and frons are separated by a distinct epistomal suture. The coronal suture running just below the median ocellus to the mid part of epistomal suture is not much prominent but even then t can be traced out. The frons has become smaller due to the enlargement of the clypeus.

The clypeus (Pl. 1 Figs. 3 & 4) is a large sclerite below or infront of frons. The post-clypeus is much larger as compared with the anteclypeus. There is a faintly marked longitudinal suture in the middle of post clypeus. The same type of suture of the clypeus has been described by Walker 1931

Apa t from the bove sclerites, there are two more sclerites each of them are situated on the lateral sides of the entire clypeus sclerite. These two scleri-

tes known as anticoxal piece of mandible (term adapted from Snodgrass) remain separated from postclypeus region by a line running at the angle of near about 50°C. The lower part of the area adjacent to the anteclypeus is strongly angulated.

Compound eyes—The head is largely occupied by a pair of well developed black-blue compound eyes. The size of compound eyes reach to such a scale that they reach transversally just at the base of the mandibles from where they are curved. The eyes are usually divided transversally in two parts. The upper portion bearing large hexagonal facets which are deeply stained as compared with the lower part consisting of smaller fecets.

The head appendages

The Antennae (Pl. I Fig 5)—The two antennae are situated on somewhat lateral sides of the vertex which are inconspicuous and dark black in colour These antennae found in the case of *Anax parthenope* are of setaceous type scarcely provided with hairs. The whole antenna consists of seven segments. The scape is stoutest and somewhat spined on its part just above the antennal socket. The pedicle which is larger than scape is clothed with feebly developed hairs and a few spines. Rest of five segments included under flagellum form the main bulk of the antenna the first being largest second slightly smaller than third one. The remaining ones are approximately equal in length The tip of the distal segment is pointed like an arrow

Mouth parts (Plate 2)

The mouth parts of the dragonfly are purely of biting and masticatory type. *The labrum* is golden yellow its sides and lower border being rounded and often notched, its middle grooved by a deep sulucus.

The labium (Fig 2 MX)—is golden yellow and consists of a median lobe and two lateral lobes. The postmentum which is about four times larger than the prementum is extended by the development of a pair of side pieces the squamae clothed with fine pubescent. These squamae have been homologized by Es ng (1931) to palp gers wh ch bear the two jointed palpi. The labial palpi are the organs forming the major part of the bulk of the lateral lobes The first segment of the labial palpus known as the lateral lobe proper terminates into a small hook l ke structure the end hook. Slightly on the external side of the end hook there is a small movable hook—the second segment of the palpus No doubt nearly the entire surface of the labrum is clothed w th small hairs but the movable hook has got a bundle of well developed hairs on its distal part.

The Maxilla (Fig 1 MX) are short massive and somewhat molar shaped consisting of a cardo st pes, the g lea and lacinia fused to form the mala. Just on the upper side of mala there is well developed lobe l'ke sl ghtly elongated, unjointed palpus which is furnished with fine bristles and hairs.

Cardo is a small triangular structure about one fifth of the stipes. The stipes is an elongated segment bearing on its distal extremity mala and palpifer Mala is also provided with about five or six bristles and palpus.

Mandibles (Fig M)—are situated just below the labrum, one on each lateral side and touching each other in the middle. These mandibles bear incisor points which may be toothed on its distal lobes, the outer surface may be named as moler lobe, though reduced but provided with an irregular masticatory surface. Except the cut edges of the mandibles which are more darker the rest surface of each mandible is smooth and dark brown having a swelling in the middle portion.

The Hypopharynx (Fig H)—is a large tongue like semi-membranous structure, the posterior part of its delicate lamina being connected with the mentum, the upper part being stronger and pilose. The upper lamina is more broader than the inferior one, clothed with imbricate spines and fine bristles.

Thorax

(Pl. 3 Figs. 1 & 3)

The thorax is divided into two major parts *viz* prothorax and pterothorax, the latter formed by the fusion of the meso and meta thorax.

The Prothorax—Though the prothorax is greatly reduced, but even then remains a distinct segment consisting of an anterior collar like lobe and narrow a middle lobe forming the greater part of the structure and lastly a posterior lobe. This latter lobe has a semicircular border and is bilobed, obtuse and often armed on its hind boarder with small spines especially in female more rarely in the male also a ruff of long stiff hairs, which interlace with a ring of shorter stiff cilia lining the margin of the occipital cavity

The Pronotum—Pronotum is a very small plate with the anterior border directed upwards. This part which is nearly concealed in the concavity of the back of the head, is a narrow and dark brown sclerite. The proepisterna is somewhat angulated on its lateral sides and is light brown in colour while the proepimeron is small elevated area which is slightly dark brown in colour

The Prosternum—Prosternum is flat and squarish sclerite, the anterior most portion of which is light brown while its posterior border is dark black having a line of small and smooth hairs. The anterior part of the eusternum is provided with a presternal suture comprising the presternum Similarly another suture on the opposite part of the eusternum comprises the sternellum sclerite which is much smaller as compared with presternum

The Propleuron—Propleuron is greatly reduced lateral sclerite of the prothorax usually of light pale colour This can be hardly differentiated into proepisterna and proepimeron

The Pterothorax—Pterothorax is usually robust and quadrilateral and if viewed and from the side it appears somewhat lozenge shaped.

The Mesonotum—Mesonotum bears the first pair of wings and is divided into an anterior notum (alinotum of Snodgrass 1935) and postnotum. The entire notum is suturally differentiated into an anterior prescutum a middle scutum and posterior one the scutellum The prescutum is separated from the middle scutum by a membrane which runs exactly in the middle of its transverse axis and is pushed into the prescutellum forming an inverted T shaped structure and dividing it nearly into two collar like lobes.

The shield shaped scutum is well developed the antero-lateral and postero-lateral sides of which are produced into anterior and posterior notal wing processes respectively The scutellum is a small median triangular sclerite which does not carry any important structure in this dragonfly

The Metanotum—Metanotum is semicircular at its anterior border and notched in the middle part. The prescutum in this case is inconspicuous and extremely reduced while the scutum is prominent nearly divided superficially into two parts by a deep groove in its middle from base to apex. Scutellum separated from the scutum by a groove in this case is not a much developed structure and lies just above the origin of abdomen

The meso and meta pleuron—In a side view of pterothorax there are to be seen three sutures i.e humeral antero-lateral and postero-lateral sutures dividing the region in mes and metaepisterna and mes and metepimera. The humeral stripe confined on the humeral suture is dark brown narrow and uniform throughout the whole length. The antero-lateral suture is faintly marked and zig-zag in its course while the postero-lateral suture is prominent deepening on its anterior and posterior sides.

The mesepisterna extends forwards and dorsalwards so as to meet infront of the mesotergum to form the mid-dorsal carina Hence the legs are pushed backwards and lie between the wing bases. The metepimera on the contrary have grown downwards and backwards usually fusing ventrally behind the metasternum On the lower part of metepisterna which is much smaller than metepimeron is situated a papilla on the summit of which opens the thoracic spiracle

The mesosternum—Mesosternum is dark brown in colour with a dark band along its middle region. The presternum of this ventre is angulated having an acute angle just in the anterior region. The most notable point about this sternum is the absence of sternellun.

The metasternum—This entire plate may be considered as eusternum as there are no visible sutures separating the presternum and sternellum The lateral boundaries of metasternum are seen to be touching the meta-pleura, meeting just above its surface

Thoracic appendages

Legs (Pl. 3 Figs. 2 4 & 5)—All the legs consist of five parts viz the coxa, trochanters, femur tibia and tarsus. There are no contiguous points of articulation between the first and second trochanter otherwise there is a articular corium between the adjacent parts of all the three pairs of legs.

Coxa has the shape of truncate cone in fore and mid-legs, but dialated in the hind legs. Each coxa bears an outer and inner articulation the inner articulation is condylar in form which fits into shallow groove on the ridge of sternum The region where the coxa meets the trochanter bears an outer set of articulation These include an anterior and posterior articulation with the trochanter The coxal suture extending from base to the anterior trochanteral articulation is well marked in the respective part of fore legs but faintly marked in the remaining two pairs of legs.

As regards the *trochanters* generally the first one is smaller robust and compressed while the second one is sub-triangular attached immovably with the femur though movable with coxa. Small rudimentary spines are present on the second trochanter of all the legs, but they are somewhat stout and strong on that of the hind-leg arranged in two rows on the dorsal side.

The *femur* is strongest and longest part of each limb It is stouter n the prothoracic leg of the male. On the flexor side of the femur is a shallow groove running along its entire length, the lateral s des of which are beset with two rows of spines These spines are best developed in the fore leg of male dragon fly The femu articulates with tibia by a condylic articulation

The *tibia* is cylindrical in form also be-set with two rows of spines on the flexor surface. Together with this a number of small spines are also pre sent on the tibiae of all the three pairs of legs. There are about ten spines on fore leg's tibia, eight to ten on mid leg and 9-11 on hind leg s tibia.

The *tarsus* of each leg is three segmented out of which the first tarsomere is slightly larger than the second one, both of them are provided with spines but much less prominent as compared with those of tibia. Ventrally each tarsus is grooved, the groove nearly covering the entire length of each trasomere. The latero-ventral sides are elevated due to the presence of this groove in the middle line. The pretarsus consists of a pair of strong lateral claw and a median claw Both of these claws are best developed in the hind pair of legs.

Wings (Pl. 3 Figs. 6 & 7)

The wings are large membranous structure of papyraceous consistency the hind wing being broader and dialated at the base as compared with fore-wing The termen i.e the posterior border of the wing meets the basal border at a sharp or rounded angle—the tornus A tornus is not a marked feature in the fore-wing The articular region of the wing consists of two

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The meta ternum—Th s ent re plate may be considered as eusternum as there are no clea sutures separating the presternum and sternellum The lateral bounda ies of metasternum are seen to be touching the meta-pleura, meet ng just above it su face

the subcostal space. Basal space is situated between RM and the base of Cu₁₁ which is bounded distally by arc. There is a space below the Cu₁₁ called as cubital space. There is a well developed grey coloured membrance at the base of both the wings. This membrane is much larger in the hind-wing as compared with that of fore-wing

Nodal index is $\frac{8-17}{11-12}\ \frac{16-9}{15-10}$

The nomenclature followed in the above description is that of Tillyard and Fraser (1938-40)

THE ABDOMEN

The abdomen is made up of ten complete segments but the inter preta tions of the terminal abdominal structure is controversial (Hanstirsch 1903; Heymons 1904 Snodgrass 1935) According to Heymon the vestiges of eleventh segment are also recognisable The union of thorax with abdomen is slightly constricted but the second abdominal segment becomes a prominent tumid structure. Subsequently again the third segment becomes constricted. All the remaining segments have got approximately a uni form breadth upto the terminal segment. Oriellets are absent on second abdominal segment while the black lateral supplementary ridges are present from segments 4 to 8

The terga as a whole are dark brown in colour but the area on the sides of the mid dorsal line is more darker The dorsum of segment 1 is olivaceous brown with a small-dark brown spot on each side. Segment 2 dorsum is tur quiose-blue traversed by a dark brown ridge. Segment 3 with a large triangu lar blue patch at each side of its base, segments 4 to 9 with jugal and accessory lateral sutures finely black, Segment 10 dorsum is black with its sides and apical border narrowly bluish-grey

As regards the *pleurites and sternites* both of them are much reduced re-presented by the banded pieces on the lateral and ventral sides respectively Along the middle line of the ventral surface the ventral plates are seen to split, their free broders being connected by a delicate black pleural mem brane which runs from the 3rd to 8th segment

The last abdominal segment is of great interest On the ventral surface just in the middle of this terminal segment there is a black longitudinal slit which is the anus. This anal opening is narrower on the anterior end while becomes broader towards the posterior end, covered dorsally by lamina the supra analis sclerite and latero-ventrally by two triangle shaped laminae the infra analis sclerites. Small hair like processes are seen to be emerging from the lam na infra analis which hang over the anal opening

Male External genital Organs (Pl 4 Figs 4 5 & 6)—The primary geni tal organ is a small papilli form eminence the seminal vesicle lying in middle

of the ventre of the ninth abdominal segment. It is covered over by two chitinous folds the preputial folds which meet in close contact over it (seminal vesicle). At the summit of vesicle there exists a gonopore.

The secondary male genital organs consist of a lamina, hamules, penis, penis sheath and penis vesicle, all situated in median depression—the genital fossa on the ventral surface of second abdominal segment. The walls of genital fossa are supported by a complex chitinous work—the genital folds which are triangular, supressed in the middle and present on the lateral sides of the fossa. Anteriorly the genital fossa is closed by a hood like structure—the lamina which is situated just below the first abdominal segment. The lamina is deeply grooved in the mid line taking the shape of bilobed structure. Lying on the lateral sides of lamina there are two pieces of anterior sternal plates. The hooked ends of these plates sometimes reach upto the lateral sides of anterior hamules. The lateral side of each of the anterior sternal plate is somewhat curved running closely to the genital folds. The anterior part of anterior sternal plates is more narrower as compared with their posterior respective parts which are more broad.

The anterior pair of hamules hanging just in front of the lamina's groove remain attached with lobe of the lamina. Both the anterior hamules lie very close to each other with their pointed hook like end directed downwards and backwards. Their pointed ends reach upto the tip of the penis sheath so as to keep the penis in position. In a few dragonflies these hooked ends were much more developed surrounding the nearest part of the penis from both the sides. The second or posterior pair of hammles is situated just in front of the mid of chitinous frame work on genital folds. The posterior hamules are rod like structures hanging on lateral side of the penis. They are quite black made of hard chitinous material.

The penis is a singular intricate organ lying in a narrow groove present in the posterior part of genital fossa. It is strongly sclerotized composed of three segments movable upon each other. The first segment protruding out from the penis vesicle a narrow rod like part is quite dark black in colour. There is a joint between the first and second segment *i.e.* next segment of the penis which is a little larger than the former one. The IIIrd segment is quite peculiar with a bulbous end having a deep groove in the middle line. Due to the presence of this groove the segment is divided superficially into two lip like lobes lying opposite to each other. It is the smallest segment touching the mouth of penis vesicle in bent condition or in rest condition in which the Ist and last segment of the penis lie in close opposition to each other as shown in the Diagram pl. I. The surface of the penis is chitinous and often grooved transversally and occasionally furnished with minute hooks.

The penis sheath meant for the protection of penis starts from the base of second segment of the penis and is heavy dark black in appearance This is also a strongly sclerotized structure bearing some longitudinal narrow grooves on its entire surface. The anterior part (i.e the part nearest to anterior hamule) is pointed while the posterior part is quite broad

The penis vesicle is a prominent bag like structure present just at the base of first segment of the penis. The opening of the vesicle which is narrower as compared with its base is of quite thick construction if observed minutely the penis vesicle is marked by several annular rings on its entire surface

The Female External Genitalia (Pl. 4 Figs. 2 & 3)—These organs are situated on the ventral surface of the ninth abdominal segment. They consist of vulvular scales, ovipositor and the styles. The vulvular scales are made up of a pair of triangular plates lying when at rest either in close opposition or slightly separated and forming more or less projecting triangular wedge shaped instrument. These broad lamellate valves terminate in a hard pointed style which is clothed by a rough bristled bundle

The ovipositor which remains hidden except at its base under the vulvular scales is a robust long slim, pointed hook like organ On removing vulvular scales the ovipositor seems to be consisting of two pieces sides by side. Each of them is broad at their base becoming narrow and pointed at their distal ends. They are hard of chitinous nature and very penetrating if touched on their distal apices.

The Anal appendages (Pl 4 Figs 1 & 4)—The superior anal appendages are of foliate type in female as well as in male but generally in male they are stouter and angular towards their inner sides with dark brown to black colour sometimes pure black on their lateral sides while light brown on their inner sides. They are provided with spines and small hairs more crowded on their inner faces at distal end, specially in the case of masculine sex.

The single inferior anal appendage which is situated just after the terminal abdominal segment is very small, very broad, less than ½ the length of superiors in female. There are about 12 14 robust spines at each outer corner of inferior anal appendage.

SUMMARY

1 The entire body of the dragonfly measures about 2 2/3" which can be divided into head thorax and abdomen.

The head is somewhat globular largely occupied by a pair of compound eyes. The important regions of the head are occiput, vertex, frons, clypeus and three ocelli.

3 The compound eyes are large structures bearing no space between them except a narrow line.

4 There is a pair of inconspicuous antenna which are seven segmented.

5 Mouth parts are of biting and masticatory type In maxilla gales and lacinia fuse to form mala

6. The thorax is divided into two parts *viz* the pro and pterothorax. The *prothorax is reduced and divided into three lobes.*

7 The mesonotum bear the first pair of wings while the metanotum bears the posterior pair of wings, both of them constructed on the same plan *i.e* they can be divided suturally into prescutum scutum and scutellum.

8. The meso and meta pleuron are also constructed on the same plan. Each pleuron being divided suturally into episterna and epimeron.

9 The sterna on the thoracic region are reduced structures, the pre-sternal region of metasternum is absent.

10 All the three pairs of legs consist of coxa two trochanters, femur tibia and three tarsi including claws.

11 The articular region of the wing contains two large strongly sclerotized plates *vi* the humeral and the axillary plate

12 The venation of the wings has been described in detail including the courses of costa sub-costa, radius media and cubitus.

13 In the abdominal region the male genital organs are confined on the ventral aspect of the second and ninth segment while the female genital organs are situated on the ventral side of ninth segment.

14 The abdomen ends into a pair of superior anal appendage and a median anal appendage in both the sexes.

EXPLANATION AND LETTERING OF FIGURES

Plate 1

Fig 1 Male *Anax parthenope* (Selys) Ventral view

2ABD	Second abdominal segment.	IXABD	Ninth abdominal segment.
AN	Inferior anal appendage.	CE	Compound eye
GF	Genital fossa.	GP	Gonopore
H	Head.	1L	Fore leg
2L	Mid-leg	3L	Hind-leg
SAP	Superior anal appendage.	TH	Thorax.
1W	Fore wing	2W	Hind-wing

Fig 2 *Lateral view of Head* Male)

ANT	Antenna	CE	Compound eye.
CL	Clypeu	E.S	Epistomal suture.
F R	Frons.	LB	Labrum.
LM	Labium.	MD	Mandible

Fig 3 Extra Clypeal region (Front view)

AGL : Ante clypeus.
PGL : Post clypeus.
LSR : Longitudinal suture.
TSR : Transverse suture.
ANX Anticoxal piece of mandible

Fig 4 Head of Male Anax parthenope (Front view)

A Antenna. E : Eye.
AGL : Ante clypeus
L Labium. M Mandible.
V Vertex. G Clypeus
FR Frons. LB Labrum.
O : Occiput.
ES Epistomal suture
CSR Coronal suture
LSR Longitudinal suture.
TSR Transverse suture.
PGL Post clypeus.
ANX Anticoxal piece of mandible

Fig 5 Antenna of Male A. parthenope

CL : Scape.
FL : Flagellum.
PD Pedicle
IVS VIIS Segment.

Plate-2

Mouth parts of A. parthenope (Male)

Fig Lb Labrum.

Fig 1MX First maxilla.

C : Carde. m Mala.
S : Stipes. p Palp
eh End hook.
mh : Movable hook.
Sq : Squama.

Fig. *M* Mandible.

Fig *2MX* Second maxilla.

ll Lateral lobe (Palp)
ml Postmentum.
ml Median lobe.
m : Prementum.

Fig *H* Hypoharynx.

Plate 3

Fig 1 Thoracic region of Male (Dorsal view)

ABD : Abdomen.
ANP Anterior notal process.
MT Metanotum
PRS Prescutum.
SL Scutellum.
TH2 Mesothorax.
AN Allnotum.
MS Mesonotum.
PNP Postnodal process.
S : Scutum.
TH1 Prothorax.
TH3 Meta thorax.

Fig 2 Mid leg of A. parthenope (Male)

G : Claw
F Femur
Tb Tibia.
CX Coxa.
IT 5T Tarsi.
Tr Trochanter

Fig 3 *Lateral view of thorax* (Male)

al : First abdominal segment.
2CX : Mid coxa.
1CX Fore coxa.
3CX Hind coxa.

em1	em3 Epimeron	es1	es3 Episterna.
1W	Base of fore wing	2W	Base of hind wing

Figs 4 & 5 *Basal region of Fore and Mid leg of Male*

CX	Coxa.	CXS	Coxal suture.
FM	Femur	ITR	First trochanter
II TR	Second trochanter		

Figs. 6 & 7 *Fore and Hind wing of Male*

1A	First anal.	Ac	Anal crossing
Al	Anal loop	C	Costa.
Cuii	Second cubital	H	Hypertrigone.
MA	Anterior median	Mem	Membrane.
N	Nodus.	Mspl	Supplementary nervure to MA
Pn	Postnodal nervure	Pt	Pterostigma
Ri	First branch of radius.	Rii	Second branch of radius.
Riii	Third branch of radius.	IRiii	Supplementary nervure to Riii
Riv	Last branch of radius.	Rspl	Supplementary nervure to I Riii.
R+M	Radius and median fused.	Sc	Subcosta.
S	Subnodus.	t	Triangle (Discoidal cell.)

Plate 4

Fig 1 *Ventral view of Female genital organs of A. parthenope*

IXABD	Ninth abdominal segment.	An	Anus.
XABD	Tenth abdominal segment.	OVP	Ovipositor
IAP	Inferior anal appendage	SAP	Superior anal appendage.
PAP	Paraproct	VSL	Vulvular scales.

Fig *Anal appendages of Female*

XABD	Tenth abdominal segment	IAP	Inferior anal appendage.
SAP	Superior anal appendage		

Fig 3 *Ventral view of IXth abdominal segment* (after removing vulvular scales)

IX	IXth abdominal segment.	OVP	Ovipositor

Fig 4 *Diagram showing ventral aspect of IXth and Xth abdominal segment male insect*

AN	Anus.
GP	Gonopore
IAP	Inferior anal appendage
PGP	Post genital plate
SAP	Superior anal appendage
VP	Vulvula plate

Fig 5 *External genital organs of Male*

1ABD First abdominal segment.
2ABD Second abdominal segment.
AH Anterior hamules.
ASP Anterior sternal plate.
CF Chitinous frame work (Genital lobe)
PEN Penis.
PH Posterior hamule.
PV Penis vesi le.

Fig 6 Lateral view f penis

I II III S First second and third segment.

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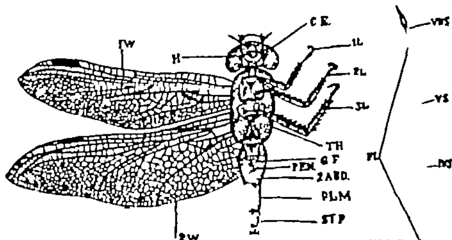
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PLATE 1







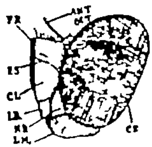


FIG 8

FIG 2

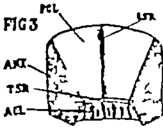


FIG 3

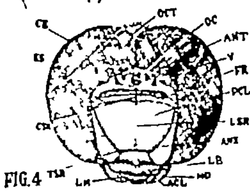


FIG.4

PLATE 2

Lb
M
b
H
s
c
1Mx
ml
ll
2 Mx

PLATE 1

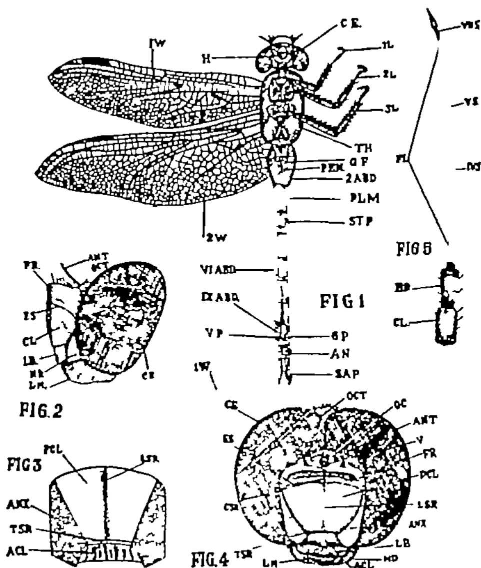

CE
1W
H
1L
2L
3L
TH
GF
PEN
2 ABD
PLM
STP
2W
VI ABD
IX ABD
FIG 1
VP
GP
AN
SAP
FIG 5
FIG.2
FIG 3
FIG.4
OCT
OC
ANT
FR
PCL
LSR
ANX
TSR
ACL
LB
LM
MD
CE
CL
ES

PLATE 4

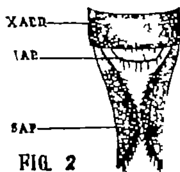


FIG. 2

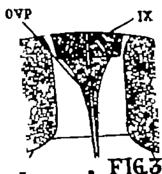


FIG. 3

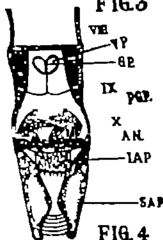


FIG. 4

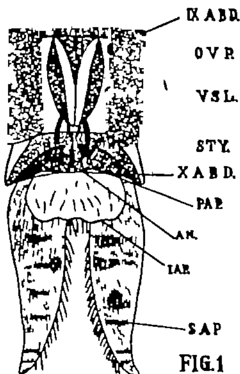
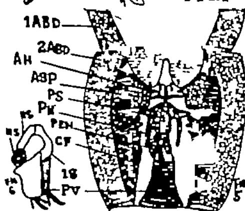


FIG. 1



SURVEY OF THE INSECT FAUNA OF NAINI TAL ODONATA—(ANISOPTERA)

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Th D S B Govt College Naini Tal

The insect fauna of Naini Tal is very rich and varied. With a view of describing the insects of this region an extensive collection of insects have been made at different times of the year The present paper deals with a few of the dragonflies so very commonly seen hovering around the banks of the Naini Lake and other riverlets.

I am grateful to Dr S P Bhatnagar Professor and Head of the Department of Zoology for his guidance and critical comments The type specimens of the new species have been deposited in the Zoology Museum of Th. D S. B Govt. College, Naini Tal for the time being

Superfamily Libelluloidea.

Family Libellulidae.

Orthetrum sabina. (Drury) (Figs. 1 2)

1907 *Othetrum sabina*, Morton, *Trans. Ent. Soc Lond.* p. 304

1909 *Orthetrum sabina* Ris *Cat. Coll. Selys'* fasc. ix, pp 180 223-225

1916. *Orthetrum sabina*, Ris *Suppl Ent. no* v p 74

1924 *Orthetrum sabina*, Fraser *J Bombay Nat Hist. Soc.* vol xxvi pp 426, 432

1931 *Orthetrum sabina* Fraser *J Bombay Nat Hist Soc* vol. xxxiii, p 446

1933 *Orthetrum sabina*, Fraser *Fauna Brit. Ind. Odon.* III : 300.

I refer to this species 3 males labelled "Bhowali 5600 ft. coll D N Sahni, 3 10 1962. The specimens before me differ from the published description in the following respects —

Pterostigma ochreous covering about 2½ cells; Cuu rather widely separated from the posterior angle of the discoidal cell. and arising from its distal side nodal index 9-12 12 9
10-9 9-11

Orthetrum gangi. Sp nov

Male—(Figs. 3-8) Abdomen 30 mm. Hind wing 33 mm *Head* lablum yellow middle lobe brownish lateral lobes dark brown frons labrum and genae glossy black clypeus yellow frons slightly grooved having a violet knob on its lower part occiput citron-yellow in centre rest dark brown. *Prothorax* brown anterior lobe shining-pale in the middle dark brown in lateral and posterior part middle lobe light yellow in middle part;

posterior lobe large rectangular fringed with long hairs light yellow and having a middle transverse groove. *Pterothorax* brown yellow with dorsum light yellow humeral and antehumeral stripe dark brown antero-lateral suture faintly marked mesepimeron with a large broad greenish-yellow band entering into the base of metepisternum with an angular out growth metepimeron also provided with a anterior apical band reaching upto half of its length. *Legs* black anterior femora with a yellow stripe on the upper surface a few long spines present on the terminal part of all the femurs hooks smaller than claws arising from middle of the latter

Wings (Figs. 3-6) hyaline a small triangular amber yellow spot present at the base of hind wing costal and subcostal antenodal nervures conciding fore wing discoidal cell not angulated, its base situated far distal to the level of arc in hind wing situated at the level of arc; one cubital nervure in all the wings sectors of arc shortly fused in fore wing with a long stalk in hind wing discoidal cell entire in hind wing, traversed by one nervure in fore wing hypertrigone entire in hind wing 2 celled in fore wing subtrigone 3 celled in fore wing disco dal field in fore wing starting with three rows of cells diverging broadly on the wing margin node lying nearer the pterostigma than to the base in fore wing but just reverse in hind wing pterostigma yellow covering about two cells anal loop closed its borders converging and meeting before the posterior border of the wing Cuii arising from the posterior angle of the discoidal cell in hind wing two rows of cells between IRIII and Rspl membrane dark grey nodal index $\frac{12\ 13}{11\ 10}\ \frac{14\ 10}{11\ 9}$

Abdomen—Dark brown segment 1 with a triangular yellow area in the middle line jugal sutures finely black on 2nd and 3rd segment from segment 3 to 7 sternites large areas of yellow colour present, the smallest being on segment 7 and biggest on 9th segment.

Anal appendages—longer than segment 10 of usual l'belluline shape. *Genitalia* as shown in figure

Holotype—Male 'Bhim Tal, 4500 ft. coll. D N Sahni 2 8. 1962, *Paratype*—Three males 'Bhowali 5600 ft., coll D N Sahni and Ch G Singh 6 9 1962

This new species runs very close to *O.sabina** (Drury) but differs in its brown prothorax, dark brown abdomen yellow pterostigma arc situated a the level of second antenodal nervure anterior femora with a yellow stripe on upper surface and finally by the absence of crowded hairs on lamina and presence of curled spine in hamule.

Sympetrum commixtum. (Selys)

1911 *Sympetrum commixtum* Ris *Cat coll. Selys fasc* 13: 621 634 635.

* Fraser F C. *Fauna Brit. Ind Odonata*, vol 3 p. 300

1919 *Sympetrum commixtum*, Fraser *J Bombay Nat. Hist.* Soc. 26 495 498.

1936. *Sympetrum commixtum*, Fraser *Fauna Brit. Ind. Odonata* 3 372 375 fig 107a.

1954 *Sympetrum commixtum*, Santokh and Baijal *Agra. Univ J Res (Sci.) III* (2) 397 figs. 28, 29

1955 *Sympetrum commixtum* Santokh and Baijal Gupta and Mathew *Agra Univ J Res (Sci.) IV* (Suppl) 746 747

I have before me 1 male labelled "Sat Tal 4000 ft. coll. D N Sahni 14.10 1962 One male "Bhim Tal 4500 ft. coll. D N Sahni, 7 7 1962.

The published description tallies exactly with the specimens before me, but the description of the wings needs a few additions which are as follows — Wings hyaline with vestigeal basal yellow marking in the hindwing 2 celled discoidal cell in forewing entire in hind wing subtrigone 3 celled hypertrigone entire distal antenodal nervure incomplete in fore wing one row of cells between IRiii and Rspl discoidal field starting with three rows of cells in forewing anal loop closed pterostigma reddish-black framed between thick black nervures nodal index $\frac{6\text{-}7\frac{1}{2}}{8\text{-}5}$ $\frac{7\frac{1}{2}\text{-}6}{5\text{-}7}$

Abdomen—brilliant red on the dorsum sub-basal spots present on either side of mid-dorsal carina from segment 5 to 8 segment 1 black segment 2 black on its apical border

Sympetrum haematoneura (Fraser)

1934 *Sympetrum haematoneura*, Fraser *Mem. Dept. Agric Ind (Ent).*, 13 70 71

1936 *Sympetrum haematoneura*, Id, *Fauna Brit. Ind. Odonata* 3 379 380

I have one male labelled on pin 'Bhim Tal 4500 ft. coll, D N Sahni 10 10 1962 The specimen before me varies in the following respects from the published description —

Head—Labium blackish-red with middle lobe black frons genae and upper part of the eyes blood red, lower part greenish-brown vesicle and occiput dark brown. *Prothorax* reddish-brown marked with black as follows — anterior lobe with the posterior half black middle lobe with the sides black leaving only a mid-dorsal stripe of ground colour posterior lobe brown, rectangular with a deep notch on its upper border and covered with long hairs. *Pterothorax* brown with black humeral stripe and a similarly coloured broad stripe present between the antero and postero-lateral sutures, both these stripes become confluent with the black colour of the ventral side leaving only two brown spots surrounded by black colour at the lower end of humeral and potero-lateral suture.

The following shall form a supplement to the description of the wings of the species which is far from complete —

Wings (Figs. 9 10) hyaline with the bases poorly coloured with yellow distal antenodal nervure incomplete in fore-wing costal and subcostal antenodal nervures conciding discoidal cell and hypertrigone entire 3 celled subtrigone in fore wing one cubital nervure in all the wings one row of cells between IRiii and Rspl discoidal field starting with 3 rows of cells node lying nearer the base than to the pterostigma in hind-wing just in middle in fore-wing anal loop closed 1A poorly developed in fore-wing pterostigma blackish brown covering about 2½ cells reticulation red upto the node especially in hind wing

Abdomen—Segment 1 brown segment 2 to 10 bloodred intersegmental joints broadly black laterally ventre of the segment 10 red. *Anal appendages*—Superior appendages double the length of segment 10 blood-red and tapering towards the apices inferior appendages broad and brown slightly smaller than the superior

Bradinopyga geminata (Rambur)

1911 *Bradinopyga geminata* Ris, *Cat. Coll. Sely fasc* 13 545 548, fig 324

1919 *Bradinopyga geminata* Fraser *J Bombay Nat Hist Soc* 26 514 515

1924 *Bradinopyga geminata*, id, *Rec Ind. Mus* 26 426 437

1931 *Bradinopyga geminata*, id. *ibid* 33 446.

1936 *Bradinopyga geminata* id. *Fauna Brit Ind Odonata* vol. 3 349 350 fig 101

I refer to this species 2 males labelled Haldwani, 1400 ft. 14 9 1962" One male labelled "Gonja Jali Farm, Haldwani, 1400 ft. coll. D N Sahni, 15.9 1962 All the specimens present before me essentially tally with the published description of the species save the colour of thorax which may be considered as local difference and not the specific one.

Macromia moorei (Selys.) (Figs. 11 12)

1921 *Macromia moorei* Fraser *J Bombay Nat Hist Soc* 27 674 683 684

1936. *Macromia moorei* id *Fauna Brit Ind Odonata* 3 164-166 fig. 50 51 and 52b

1932. *Macromia trituberculata* Needham, *Rec Ind. Mus* 39 211 212.

1950 *Macromia moorei fumata* Lieftinck, *Treubia* 20 711

To this species I refer 3 males labelled and one female labelled "Kherna, Garam Pani 3500 ft coll. D N Sahni and D C Gangola, 20 10 1962.

The following forms a supplement to the description of the species which have been rather incompletely described by the previous authors—Sides of the thorax marked with bright yellow broad stripe in the region of metepisternum

this stripe being extended on the dorsum and confluent, rest of the thorax bright metallic green, the posterior portion changing to dark brown. Hypertrigone traversed by 2 to 3 nervures in forewing Apart from this the frons is brownish-yellow without metallic reflex resembling to a species reported from Simla. In the case of female wings are rounded tinted yellow distal to nodus covering the area upto the end of Riv-v anal loop 12 celled abdomen very much compressed laterally with broad annules segment 10 brown superior anal appendages brown and shortly conical vulvular scales short and emarginate.

Superfamily Aeshnidea.

Family Gomhidae.

Acrogomphus malani Sp. nov (Figs. 13-17)

Male—Abdomen 35 mm. *Hind* wing 31mm *Head*-labium middle lobe black, lateral lobes light green labrum black mandibles and frons light green clypeal region black with a light green spot on lateral sides of the anteclypeus; vertex and occiput black eyes dirty green *Prothorax*—Anterior lobe bright pale middle lobe black with two lateral and one middle large yellow spots posterior lobe small collard yellow and fringed with long hairs *Pterothorax* light green marked with black mesepisternum with two black and two light green alternating bands running towards the dorsum humeral stripe black metepimeron traversed by a dark black band running towards the dorsum mesepimeron tinched creamy *Legs* black with light yellow band on the flexor surface of the anterior femora tibia provided with two rows of closely set spines hooks smaller than claws and arising from middle of the latter

Wings (Figs. 13 14 15 16) hyaline tornus angulated five transverse nervures from arc to the bifurcation of Rs in forewing three in hindwing; four rows of postnodal cells in hindwing, first postnodal cell divided into two; anal loop 2 celled anal triangle 3 celled discoidal cell, hypertrigone and subtrigone single celled discoidal field starting with 2 rows of cells in fore wing, diverging broadly on the wing margin costal side of the discoidal cell in hind wing much longer than that of fore wing sectors of arc separated Cuii and 1A nearly parallel; arculus lying opposite to second antenodal nervure in hindwing; pteostigma dark brown covering more than three cells; membrane feebly developed and dirty brow in colour nodal index $\frac{10\text{-}14 \quad 17\ 11}{10\text{-}14 \quad 12\ 11}$

Abdomen long and cylindrical black interrupted with light green as follows—segment 2 with two dorso-lateral bands; segment 3 with long thin stripe on either side of mid-dorsal carina segment 4 to 6 with one apical spot on dorso-lateral side segment 7 provided with one basal and one apical spot on either side; segment 8-9 with spots on lateral sides and slightly winged. *Anal*

Fraser F C. *Fauna Brit. Ind. Odonata* 3, p. 164

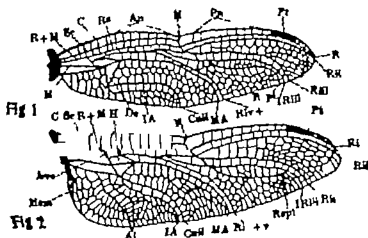
appendages dark brown superior appendages slightly curved and forcipate inferior appendages (Fig 17) branched, hook shaped, curved branches broad at the base and pointed at the apices. *Genitalia*—Lamina broad and slightly arched anterior hamules long and narrow ending into a bifurcation, the hook like curved spine directed upwards, the second process is somewhat broad and directed downwards posterior hamules broad and flattened genital lobe moderately large, scoop shaped and black.

Holotype—One male labelled "Bhim Tal, 4500 ft coll. D N Sahni, 10 10 1962 *Paratype*—Three males labelled Bhowali, 5600 ft. coll D N Sahni & Ch. G Singh 3 10 1962"

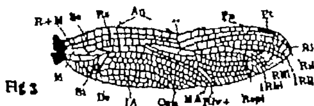
This new species runs very close to *A. frateri* but can be distinguished by its relatively smaller size, black clypeus with one light green spot on the lateral side of anteclypeus pterothorax light green marked with black, wings hyaline, no golden yellow colour near the base of the wings and its nodal index. Apart from the above the shape of anal appendages and genital organs differ considerably

LETTERING OF THE FIGURES

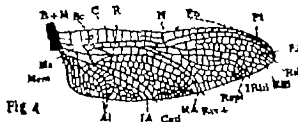
1A First anal.
AH Anterior hamule.
An : Antenodal nervures.
At : Anal triangle.
Cuii Second cubital.
Dc Discoidal cell.
GL Genital lobe.
LN : Lamina.
Mem Membrane.
N : Nodus.
Pn : Postnodal nervures.
Ri First branch of Radius.
Riii Third branch of Radius.
1Riii Supplementary nervure to Riii.
Rspl Supplementary nervure to 1Riii
Riv-v Last branch of Radius.
R M Radius and Media fused.
Rs Radial sector
Sc : Subcosta
Sn Subnodus.
St Subtrigone.
Ac : Anal crossing
Al : Anal loop.
Arc Arculus.
C Costa.
Cu : Cubital space.
Df Discoidal field
H Hypertrigone.
MA Anterior median.
Ms Median space.
O Oblique nervure
Pt : Pterostigma.
Rii Second branch of Radius.



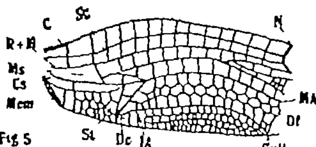
Orthetrum sabina. Fig1 Fore wing Fig2 Hind wing.



Orthetrum canal sp. nov Male Fore wing



Orthetrum canal, sp. nov. Male Hind wing.



Orthetrum canal sp. nov Male Base of Fore wing.

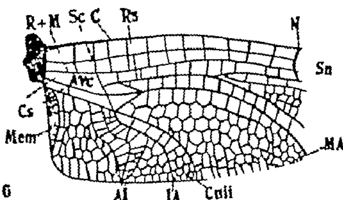


Fig 6

Orthetrum canal sp nov Male Base of Hind wing enlarged

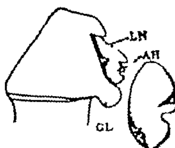


Fig 7

Orthetrum canal, sp. nov Male

Fig 7. Genitalia lateral view Fig 8 anterior hamulus enlarged.

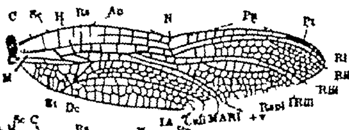


Fig 9

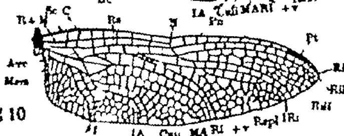
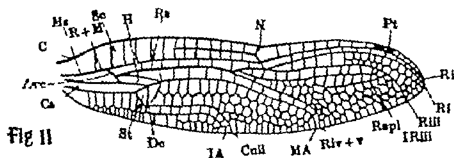
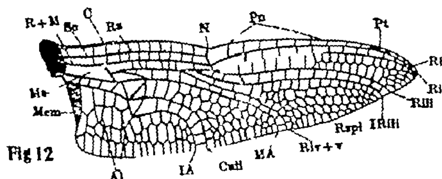


Fig 10

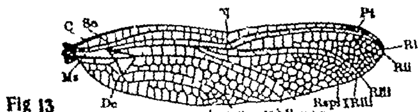
Sympetrum haemato neura Fig 9 Fore wing Fig 10 Hind wing

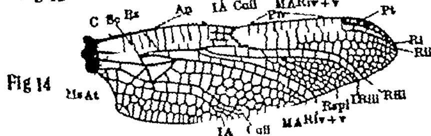


Macromia moorei Male: Fore wing



Macromi moorei Male hind wing





Acrogomphus mohani sp nov Male. Fig13 Fore wing. Fig14 Hind wing

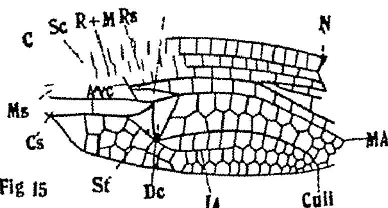


Fig 15

Acrogomphus mohani, sp. nov Male Fore wing Base enlarged

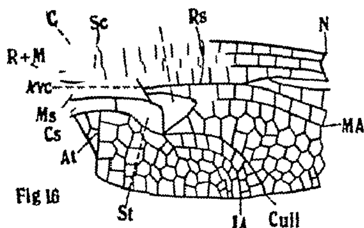


Fig 16

Acrogomphus mohani sp nov Male Hind wing Base enlarged

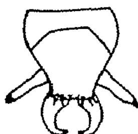


Fig 17

Acrogomphus mohani sp nov Male Anal appendages

EFFECT OF PLANT REGULATORS AND CONCENTRATIONS OF THEIR SOLUTION ON PARTHENOCARPY IN TOMATO

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The edible part of many of our important vegetables is their fruit but unfortunately most of them are highly seeded which makes them less valuable. They would be more palatable and hence better relished if they were seedless. Among such vegetables tomato is by far the most important.

With the discovery of hormones in plants, various attempts have been made to find out the efficacy of different chemicals that can be used to produce *parthenocarpic and at the same time seedless fruits* Among the various methods suitable for the production of such fruits, spraying has been found to be the most practical one. Gardner and Marth[1] obtained such fruits in a number of species by this method. Similar results were also obtained by Rappaport Maharana and Singh[8] and others.

Out of the many plant regulators used for this purpose Indole 3 butyric acid (IBA) and a-naphthalene acetic acid (NAA) are reported to have given the best result in many crops[1 8 10] The response to the treatment of different kinds of plant regulators and their concentrations has, however been found to be conditioned by variations in climate and soil factors. It was, therefore, thought desirable to find out the efficacy of these two plant regulators applied by spraying in various concentrations for our conditions.

MATERIALS AND METHODS

The two plant regulators (IBA and NAA used in this experiment were applied by spraying in concentrations of 200 400 600 and 800 ppm. This gave 8 treatment combinations. Spraying of only the carrier (absolute alcohol+distilled water) and control (no treatment to tagged flower buds) gave in all 10 treatments which were laid out in the field by randomised block design replicated four times.

Seeds of Marglobe variety of tomato were obtained from Vegetable Specialist, Vegetable Breeding Sub-station Katrain (Kulu Valley) and were sown in the nursery on 1 10-1962 Four healthy seedlings were transplanted in each of the experimental plots on 28-10 1962 at a distance of 90 cm. on either side Proper cultural care was taken as for the normal crop Early isolated inflorescences were removed and when sufficient number was available flower buds of each plot were sprayed by the requisite concentration of the

plant regulator concerned on 15.1.1963. Three fruits were harvested at random from each plot at maturity for the study of various characters.

RESULTS

Number of seeds per fruit

The two plant regulators differed markedly in their effect on the number of seeds per fruit. The average number of seeds per fruit under the treatment of IBA was 23.13 but this was significantly reduced to 2.75 in the case of NAA (Table 1). Thus, NAA was much more effective than IBA in reducing the seed content of tomato fruits. There was a gradual reduction in the number of seeds per fruit with the increase in concentration of the two plant regulators individually as well as collectively but even the lowest concentration of NAA was more effective in reducing the number of seeds than the highest concentration of IBA. Since completely seedless fruits were obtained in the case of NAA at 600 ppm, there was no question of any better effect beyond this concentration. In the case of IBA, still higher concentrations would be necessary for the production of completely seedless fruits since even at the highest concentration (800 ppm) there were on an average 8.75 seeds per fruit. It may also be pointed out that there was practically no difference between control and 0 ppm on the number of seeds in the fruits.

TABLE 1

Number of seeds per fruit

Treatments	0 ppm	200 ppm	400 ppm	600 ppm	800 ppm	Average	C. D for plant regulator @ 1%
IBA	123.00	40.73	25.00	18.00	8.75	23.13	9.33
NAA		8.00	5.00	0.00	0.00	2.75	
Average	123.00	4.38	14.00	9.00	4.38		
C. D for concentration @ 5			11.21				
@ 1			13.43				

Viability of pollen grains and percentage of fruit set

The two plant regulators did not differ much in their effect on the viability of pollen grains (Fig. 1). In both there was a gradual increase in the viability of pollen grains with the increase in concentration upto 600 ppm, but beyond this, there was marked reduction in this respect in both the cases. When compared to control the viability at 600 ppm was more than double.

In respect of fruit set also there was not much difference between the two plant regulators. The percentage of fruit set was not affected much in both the cases upto 600 ppm, but beyond this there was some reduction in it.

Size of fruits

The kind of plant regulators produced significant effect on the weight per fruit. The average weight of fru ts under the treatment by IBA was 35 38 gm. but t was significantly reduced to 16 93 gm in the case of NAA (Table 2) Thus, reduction in the weight per fru t was more marked under the treatment by NAA in comparison to IBA. The increase in concentration of the two plant regulators ind v dually as well as collectively had, on the whole, an adverse effect on the weight per fruit *i.e.* vith the increase in conce ntration the weight per fruit was reduced gradually except in the case of ?00 and 400 ppm where the average weight of fruits was almost the same It may also be mentioned that the results in respect of volume and diameter of fruits were of a s m la nature.

TABLE 2

Weight per fruit in gm.

Treatments	0 ppm	200 ppm	400 ppm	600 ppm	800 ppm	Average	C. D. for plant regulator @ 1%
IBA	56 17	43 02	43 30	32 42	22 77	35 38	8 49
NAA		21 55	21 77	15 60	8 80	16 93	
Average	56 17	32 29	32 54	24 01	15 79		
C. D. for concentration @ 5%			9 98				
@ 1%			12 00				

Weight of fruit per seed

Since the treatments of this experiment were associated with a eduction in the size of fruits along with th reduction in the number of seeds per fruit, it was interesting to find out as to which of these two characters was affected more by the treatments. It would be seen in table 3 that the weight of fruit per seed was more than double in the case of NAA as compared to IBA and the increase in concentration also increased the weight. It is thus l that the effect of the treatments was more marked on the reduction in seed content

TABLE 3

Weight of fruit per seed in gm

Treatments	0 ppm	200 ppm	400 ppm	600 ppm	800 ppm	Average
IBA	0 66	1 51	2 09	2 16	3 11	2 22
NAA		4 19	5 71			4·95
Average	0 66	2 85	3·90			...
C. D for concentration @ 5			1 35			
@ 1%			1 86			

*Fru ts were completely seedless in these cases.

Matur ty f fru ts

Under NAA fruits eached edible maturity 4 days earlier than those under IBA (Table 4) Increase in concentration was also associated with a gradual reduction in the number of days equired for reaching maturity with the esult that at 800 ppm the fruits r pened 9 days earl er in comparison to 0 ppm.

TABLE 4

Number f day betw en t eatment f flower buds and harvest of fruits at maturity

T eatmen	A erage numbe of da for maturity
IBA	80
NAA	77
0 ppm	81
00 ppm	79
400 ppm	78
6 0 ppm	77
800 ppm	75

DISCUSSION

The find ngs of the p esent experiment have hown that both the plant regulator IBA and NAA pr du ed parthenocarpic fruit of tomato

(Plate 1) These results are in confirmity with the findings of Zimmerman and Hitchcock[10] Singh and Kacker[9] Randhawa[8] and some other workers who also studied the effect of these plant regulators on this crop. Similar results have been found in some other crops also (Gustafson[3] Tyagi Konhar and Singh[7])

Gustafson[3] reported that in the case of natural parthenocarpy occuring in banana, seedless grapes etc., the ovules or perhaps the ovary itself produce auxins which make ovary to grow into a fruit without fertilization or even without the stimulus from pollination. It was, therefore, concluded that fruit formation was controlled by phytohormones or auxins contained in the flowers. If these could be supplied from out side fruits will be formed even without the stimulus that comes from normal pollination and this was achieved in this experiment by the application of plant regulators.

In the present experiment NAA gave a better performance than IBA for inducing parthenocarpy in tomato. The work of Zimmerman and Hitchcock[1] revealed that NAA was the best out of IAA, IBA, IPA and NAA even at dilution of 1 ppm. Maharana and Singh[4] found that NAA was more effective than IBA in watermelon. The explanation for the superiority of NAA over IBA may be that the stimulus produced by this plant regulator is more closely related to the natural one produced in the plant for the development of fruits.

In producing parthenocarpic fruits by the use of plant regulators many workers found that there was a positive correlation between the size of fruits and number of seeds in them[3,4] The results of this experiment have also shown that reduction in seed content was associated with a reduction in the size of fruits. Gustafson on the other hand, reported that seedlessness and size of fruit were often independent of each other At this research station also Tyagi et al[9] found that in the case of Tinda, application of NAA produced fruits of the same size even when the number of seeds per fruit was reduced from 208 4 of the untreated fruits to 1 1 produced by 800 ppm of this plant regulator It is thus very interesting that the same plant regulator produces different effects on the relationship between seed content and fruit size on different crops under similar conditions.

The weight of fruit per seed increased with an increase in the concentration of plant regulators. This was so because the effect of the chemicals was more marked on the reduction of seeds than that of fruits.

The viability of pollen grains increased from 32·4% of 0 ppm to over double at 600 ppm in both the plant regulators but the percentage of fruit set was not affected much upto this concentration. It appears that the beneficial effect of the plant regulators in improving the pollen viability is counteracted in some other way by adverse effects resulting in no improvement in fruit set Beyond 600 ppm, however there was reduction in both these aspects perhaps because of adverse effects on both of them

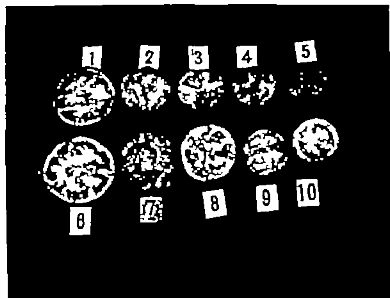


Plate 1 Effect of concentrations of the two plant regulators on parthenocarpy in Tomato. 1=0 ppm, 6=Control, 2 to 5 NAA and 7 to 10—IBA 200 400 600 and 800 ppm respectively

THE AIR BLADDER AND THE WEBERIAN OSSICLES OF *TOR PUTITORA* (HAMILTON)

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INTRODUCTION

Teleostean fishes of the order Ostariophysi are distinguished by the possession of a chain of bony ossicles connecting the air bladder with the internal ear. Weber (1820) was the first to describe this elaborate chain of ossicles and later Sagemehl (1885) proposed the order Ostariophysi (Cypriniformes of Berg 1940) for fishes that have the Weberian ossicles.

These structures have been studied in Indian fishes by several workers, such as Hora (1922), Ramaswami (1952, 1955), Mookerjee *et al.*, (1955) and Karandikar and Masurackar (1954). The taxonomic and phylogenetic significance of the Weberian apparatus as a whole has also been studied by various authors. Evans (1925) worked out the anatomy and physiology of the air-bladder and the Weberian apparatus of twelve species of Cyprinoid fishes. Watson (1939), Nelson (1948-1949) and Martin (1961) have added to our knowledge of the Weberian ossicles in a variety of species. In connection with my work on the anatomy etc. of the hill-stream fish, *Tor putitora* (Hamilton) a major carp which is commonly found in the rivers and rivulets of the Doon valley, I made a special study of its air bladder and the associated structures. The result of this work are presented in this paper.

MATERIAL AND TECHNIQUE

Tor putitora (Hamilton) which belongs to the family Cyprinidae of the order Cypriniformes, is generally known as the Mahseer. The morphology of its air-bladder was studied by detailed dissections of freshly caught specimens. For dissection of the Weberian ossicles, the fish after removing the scales were kept in moderately hot water for about thirty minutes. This rendered the dissection of the muscles easier but longer immersion in the hot water dissolved out the inter-ossicular ligaments by which the ossicles are connected with one another. The ossicles after removal from the fish for further cleaning were treated with 1% solution of Potassium Hydroxide and later on bleached with Hydrogen peroxide. The fatty tissue in which the tripus is embedded was dissolved with petroleum ether or acetone.

The diagrams were prepared with the help of a camera lucida.

OBSERVATIONS

The Air-bladder

The air-bladder of *Tor putitora* is an elongated glistening structure lying in the abdominal cavity below the vertebral column, and separated from it by the kidney. In a 33 cm. long fish the air-bladder was found to be 13 cm. long

The air-bladder is divided by a deep constriction (Fig 2) into an anterior and a posterior portions. The anterior portion runs close to the vertebral column anteriorly and terminates below the fourth vertebra where it lies between its two prominent transverse processes. Dorsally the air-bladder has a notch which fits into the ventral ridge of the fourth vertebra. The posterior portion of the air bladder is g eatly elongated and extends almost up to the vent.

The long thin pneumatic duct arises ventrally near the anterior margin of the posterior portion of the air bladder It runs upwards and forwards along with the oesophagus and opens into it on its ventral surface. The opening of the pneumatic duct into the oesophagus is guarded by a strong sphincter muscle.

The blood supply of the air-bladder is through the pneumatic artery a branch of the dorsal aorta. A branch of the vagus nerve also enters the air bladder along with the pneumatic artery

Histologically the structu e of the wall of the air bladder is different in its two portions. The wall of the anterior portion of air-bladder is constituted by the following layers (fig 3) (*i*) the outer tunica externa is of the nature of a dense collagenous fibrous tissue (*ii*) the submucosa is constituted by a loose connective tissue layer (*iii*) the muscularis mucosa consists of a thick layer of smooth muscle fibres with prominent nuclei; (*iv*) the lamina propria is formed of a th n layer of connective tissue and (*v*) the innermost single layer of somewhat compressed epithelial cells. The wall of the posterior portion lacks the tunica externa and is comparatively thinner and more transparent.

In f ont the air bladder is in intimate association with the complex cha n of Weberian ossicles.

THE WEBERIAN OSSICLES

Four small independent bones which are developed on either side of the anterior vertebrae constitute the Weberian ossicles (Fig 1) These articulate with one another forming a chain. Two small bony pieces—the claustrum (*cl*) and the scaphium (*sc*) are developed on the lateral sides of the centrum of the first vertebra. They are capped on the top by a median bony piece which completes the neural ar h in this region The claustrum and the scaphium form the anteriormost elements in the chain of Weberian ossicles. A flattened triangula bone tripus (*t*) lies on e ther side of the centrum of the fused second and th rd vertebrae The tripus rests anteriorly on the stout transverse processes of the second vertebra and has a narrow process at its posterior side, this is firmly attached to the antero-later l side of the air-bladder by strong ligaments. It is provided with a good number of fenestrae which are filled with fat in the living condition. The anter or amus is normal while the transformator process is curved and fits into the not h of the a bladder Its articulating surface is well developed. The t pus forms the fourth and the posteriormost element of the Weberian ossicles In f ont t is connected with the auditory capsule

through the chain of complex bones consisting of the intercalarium (in.) the scaphium (s.) and claustrum (cl.) Stretching in between the scaphium in front and the anterior end of the tripus behind, there is a stout ligament on either side, in which is embedded a small rodshaped bony piece with a short inwardly directed spiny process—the intercalarium. Its proximal part is bifurcated, and it forms the third link in the series of the Weberian ossicles. These bones thus form a connecting chain between the air-bladder and the internal ear on either side of these the tripus presses against the anterior wall of the air-bladder while the scaphium fits into the membranous covering of the posterior paired opening of the atrium.

DISCUSSION

In general the morphology of the air bladder of *Tor putitora* follows the same basic pattern as observed in other Ostariophysi. In view of Fange's (1953) critical work I have designated the two constituent parts of the air-bladder as the anterior and posterior portions rather than the anterior and posterior chambers.

The general plan of the organisation of the Weberian ossicles in *Tor putitora* does not differ materially from that in other Cyprinoid fishes. The nomenclature followed by me is as suggested by Martin (1961)

The claustrum and scaphium do not show any major structural differences as compared to those of other fishes. The intercalarium which is embedded in the inter-ossicular ligament, is an elongated rod-shaped structure. It is bifurcated proximally Ramaswami (1952) designated these processes as the ascending and the articular processes. These processes in different fishes, show a great diversity in shape, size and structure and might serve to some extent as a taxonomic character Various workers, however have considered these variations as of little importance for taxonomic work (Hora 1922 Evans, 1925 and Ramaswami, 1952 55) Generally the two processes are almost equal in length in Cyprinoid fishes but in *Tor putitora* the ascending process is comparatively much shorter

The articulating process of the tripus is comparatively well developed in *Tor putitora* but its transformator process which fits into the notch of the air bladder is greatly curved. The extreme fenestration of the body of the tripus in *Tor putitora* has not been mentioned by earlier workers.

ACKNOWLEDGEMENTS

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The author is also indebted to Dr M. L. Bhatia and Dr M. Chandi for the encouragement, guidance and valuable suggestions.

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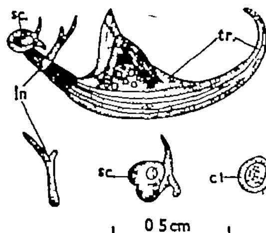


Fig 1

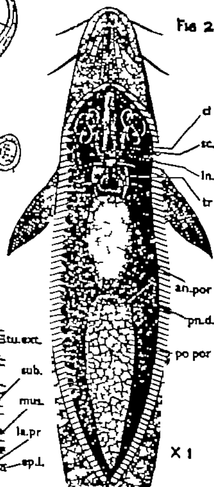




Fig. 3

Fig 1 Ventral view of the Weberian ossicles. *cl.*, claustrum; *in.*, intercalarium; *sc.*, scaphium *tr* tripus.

Fig. 2. Swim bladder and the Weberian ossicles in ventral view *an. por* anterior portion of the air-bladder; *cl* claustrum *in.*, intercalarium; *pn. d.*, pneumatic duct; *po. por* posterior portion of the air-bladder; *sc.*, scaphium *tr* tripus.

Fig 3. A part of T. S. of the anterior portion of the air-bladder *ep. l.*, epithelium; *la. pr* lamina propria; *mus* muscularis mucosa; *sub.*, submucosa *tu. ext.*, tunica externa.

STUDIES ON CHANGES IN PROTEINS DURING HUMIFICATION OF EUPHORBIA HIRTA (DHUDHIA) LEAVES

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Abstract

Proteins in O.M. (organic matter Dhudhia Leaves) treated soil (soil mixed with Dhudhia leaves 20 1) soil (from uncultivated land of Agra Coll ege, Agra.) have been extracted by different solvents (distilled water 10% NaCl, 0.2% KOH and 70-80% ethanol) Results show that the decomposi tion of ethanol soluble proteins is maximum in all the three cases *i.e* O M., T.S (Treated Soil) and soil. Decomposition of total proteins is greater in the case of T.S as compared to O.M. and soil, with the result mineralisation of inorganic nitrogen is also more in the case of T S This emphasizes the role of micro-organisms which develop in the soil during humification. The rate of protein breakdown increases with the increasing rate of decomposition of carbohydrates.

The order of decomposition of these proteins during humification of leaves is as follows :—

Ethanol (70-80%) soluble proteins>alkali (0.2% KOH) soluble proteins>water soluble proteins>saline (10% NaCl) soluble proteins.

In the case of T S. saline solubl fraction of proteins increase which may be due to conversion of water alkali and alcohol soluble fraction of proteins to saline soluble fraction of proteins to some extent.

The order of decomposition is as follows :—

Alcohol soluble> water soluble> alkali soluble.

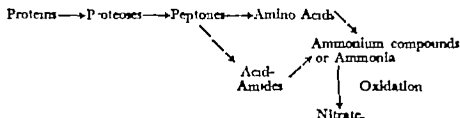
From the greater decomposition of proteins in the case of T S., increase of inorganic nitrogen and pH ranging between 7 to 8 It has been suggested that Dhudhia leaves, though nonleguminous, may prove to be a potential green manure.

Introduction

Proteins, which are one of the major essential constituents of all living cells, are naturally occuring extremely complex combinations of aminoacids. These are the storehouse for most of the organic nitrogen.

During the protein decomposition in nature micro-organisms synthesise extracellular proteolytic enzyme which acts best at the pH range 7-8 This

enzyme hydrolyses proteins to amino acids via proteoses and peptones. The major end products of protein breakdown are CO_2, ammonium sulphate and water. The ammonia so liberated may be either (a) assimilated by soil organism and again synthesized into proteins or (b) adsorbed by colloidal substances in soil and bound as ammonia or (c) acted upon by other soil forms and oxidised first to nitrites and then to nitrates. Protein amplification probably progresses as follows :—



A large part of the protein or protein rich compounds added to soil is recovered in the mineral form. Some of the proteins, however may combine *with lignin and other resistant compounds and become a part of the soil* humus. Once the aminoacids are formed they are deaminized by several methods and ammonia so obtained is changed to nitrates, the form which higher plants take up in large proportion of their nitrogen requirement. The rate of mineralization is influenced by the pH of the environment. The production of inorgani nitrogen is greater in alkaline than in acid soils

The rate of protein breakdown depends upon C N ratio amount of lignin and that of a ilable carbohydrates A low nitrogen content or a wide C N ratio is associated with slow decomposition [1] The more is the amount of lignin the less will be protein breakdown as proteins form ligno-proteins complex with lignin with the result that the rate of nitrogen mineralization i retarded [2]

The carbohydrates have retarding effect on the decomposition of proteins due to assimilation of ammonium by the additional organisms appearing in the decomposition of carbohydrates or to a microbial preferen e for the carbohydrate, to the pr tein [3]

EXPERIMENTAL

The techniq e of Crowther and Mirchandani[4] and Daji[5] was used for the humification of O M (powdered Dhudhia leaves) T S (soil mixed with O M 70 1) and soil. Samples were taken out at every fortnight as described in our previou commun c tion (Agra Univ J Res. Vol XII Pt. I Jan 63) From ea h mple of O M, T S and soil proteins were extracted by successive treatment with di t lled water 10 N Cl 0.2% KOH and 70-80 eth anol [6]

20.0 g of powdered n l sieved O M 400 g of T S and 400 g of soil were shaken separat ly w th 400 of di tilled water for bout 6-8 hours in

an electrical shaker and then filtered. Residue was shaken with 400 cc. of 10% NaCl in an electrical shaker for about 6-8 hours and filtered. The residue so obtained was shaken in electrical shaker with 400 cc. of 0.2% KOH for 6-8 hours and filtered The final residue so obtained was shaken with 400 cc. of 70-80% ethanol in an electrical shaker and then filtered. The aqueous, saline, alkaline and alcoholic extracts so obtained were dialysed in a Grahm's dialyzer The dialysis was carried out till the dialysates started giving negative test for ions. This indicated the completion of dialysis which took about seven to ten days. After dialysis these extracts were dried and weighed. In the case of soil only overall changes in proteins in different extracts was observed at the end of 105 days of humification

pH was determined in each sample.

Tables 1 2 and 3 represent the amount of proteins in different extracts of 100 g of O M T S and S respectively Table 4 shows pH observations in different samples of O. M T S and soil Observations on changes in amount of total nitrogen, organic nitrogen and mineral nitrogen have been communicated in our previous paper (Agra Univ J Res. Sci., Vol. XII Pt. 1 Jan. 1963) however these observations have been utilized here to explain the changes in proteins

Discussion

Graph I shows that during humification of O M. alone proteins extractable by water first increase by 4·2% upto 30 days then decrease very much (40%) at the end of 105 days of humification Total proteins also increase upto 30 days. During the same period organi nitrogen increases and mineral nitrogen decreases. Saline (10% N Cl) and alkaline (0 2% KOH) fractions of proteins also increase upto 30 days From these observations it is inferred that mineral nitrogen is being inmobilized to water soluble proteins by the micro-organisms due to their high multiplication. It is observed that alcohol soluble proteins decrease sharply in the beginning upto 45 days then they decrease gradually Dur ng this period, saline and alkaline fractions of protein also increase so it is probabl that alcohol soluble proteins might have been converted to saline and alkaline fra tions of proteins before being mineralized. Total proteins decrease gradually after 30 days and at the end of 105 days decomposition was observed by 50·5% In table 1 it is observed that the rate of protein decomposition increases with the decreasing amount of lignin and the decomposition is maximum after 105 days when the amount of lignin is minimum. Our observations have been fully supported by those of Bremner and K M. Shaw[8] In table 1 it is observed that as the rate of protein breakdown increases C/N ratio (previous paper Agra Univ J Res. Sci., Vol. XII, Pt. 1 Jan 1963 issue) narrows, a fact supported by the views of F E. Allison, M. S Sherman[1] etc.

In graph I mineralization in the case of O M takes place fter 60 days and reaches to a maximum at 75th day after which it goes down.

After 105 days of humification mineralization is 41 8% increase in total nitrogen is 27·9% In graph I the decrease in mineral nitrogen after 75th day and increase in organic nitrogen during the same period suggests that mineral nitrogen is being converted to organic nitrogen which is not in the form of protein may be in the form of aminoacids or their salts

In the case of T S (graph II) water soluble proteins decrease gradually and decomposition is 86% at the end of 105 days of humification Alkali soluble proteins first decrease upto 30 days then increase by 1 78% at the end of 45th day followed by gradual decomposition upto 82 22% at the end of 105 days. Proteins in saline extract increase gradually and the increase is maximum at the end of 30th day At the end of 105th day increase in proteins of saline extract is 84% Total protein decomposes gradually till finally it reaches to 60 5% at the end of 105th day The increase in proteins of saline fraction may be due to conversion of water alcoholic and alkali soluble proteins into saline soluble fraction of proteins. It appears that decomposition of water alcoholic, and alkali soluble proteins occurs via saline soluble fraction of proteins.

In the case of soil alone (table 3) decomposition of total proteins occurs by 33·3% and saline soluble fraction of proteins increase at the end of 105 days. Decomposition is maximum in alcohol soluble fraction (nearly 70%) From these observation in O M. T S and soil it may be concluded that alcohol soluble proteins are easily decomposable. Greater decomposition of proteins in the case of T S may be due to high microbial activity

In the case of T S (table 2 graph II) mineral nitrogen decreases upto 45 days but there is no increase in protein content of T S during the same period while the organic nitrogen increases. It appears that inorganic nitrogen has been converted to organic form other than proteins may be in amino acid or their salts

Due to greater decomposition of proteins (graph II) in T S as compared to O M. the increase in inorganic nitrogen in T S may lead to increased fertility of soil. Hence Dhudhla leaves though nonleguminous may be used as green manure for the less fertile soils

Observations on pH measurement also favour this O M. to be used as green manure The pH of T S during 75-105 days remains in the vicinity of 7 to 8, and this is optimum range for the activity of extracellular proteolytic enzymes which decompose proteins and in this range rate of mineralization is maximum during the period from 75 days upto 105 days which may be due to *high enzyme activity and high* bacterial activity In the case of O M. and T S both it is observed, that the rate of protein breakdown (table 1 and 2) increases with the decreasing amount of carbohydrates (table 1 and 2 previous paper A. U J R., loc cit.) which proves that micro-organisms prefer a carbohydrate substrate as a source of energy as compared to proteins. This is supported by Martin [8]

Studies on stem part of this plant are in progress to determine its effect on the fertility of soil.

ACKNOWLEDGEMENTS

The authors express their sincere gratitude to Prof. A. K. Bhattacharya, D. Sc., F. R. I. C. (Lond.), Professor Emeritus, Agra College, Agra, for his valuable suggestions from time to time. They are also thankful to the Secretary, Ministry of S. R. and C. A. for awarding a research scholarship to one of them (M. M. V. Tandon).

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TABLE 1

Changes in amount of proteins in different ext acts Total nitrogen Organic nitrogen, Mineral nitrogen and Lignin from 100 g of O M (Dudhia leaves)

Time in No. of days	Weight in gms. I aqueous extract	Weight in gms. in saline extract	Weight in gms. in alkaline extract	Weight in gms. in alcoholic extract	Total Proteins in gms.	Total nitrogen	Organic nitrogen	Mineral nitrogen	Lignin
0	5 0	4 08	3 83	5 47	18 40	3 22	2 073	0·1500	11 5
15	5 12	5 31	3 23	3 42	19 08	2 95	2 866	0 0867	11 2
30	5 21	6 83	6 73	1 71	20 50	2 47	2 4365	0 0335	10 8
45	3 28	5 1	4 09	1 61	14 08	3 38	3 31	0·0693	10 6
60	3 5	3 86	3 49	1 09	11 94	3 02	2 8736	0 1564	10·3
75	2 91	2 89	2·92	1 01	9 73	3 599	3 2182	0 3008	10 2
90	2 67	2 68	2 89	0 92	9 37	4 099	3 8721	0 2262	10 18
105	3 0	3 1	2 15	0·85	9 1	4 12	3 908	0 2433	10 14

TABLE 2

Changes in amount of proteins in different extracts, Total nitrogen, Organic nitrogen, and Mineral nitrogen from 100 g of T S

Time in No. of days	Weight in gms. in aqueous extract	Weight in gms. in saline extract	Weight in gms. in alkaline extract	Weight in gms. in alcoholic extract	Total Proteins in gms.	Total nitrogen	Organic nitrogen	Mineral nitrogen
0	0 47	0 25	0 45	0 5078	1 6778	0 168	0 1507	0 01233
15	0 561	0 371	0 361	0·324	1 457	0 1416	0 1512	0 0096
30	0 256	0 562	0 326	0 152	1 296	0·122	0 113	0 00898
45	0 508	0 49	0 458	0 205	1 566	0 181	0 1692	0 01178
60	0·101	0 503	0 29	0 095	0 789	0 182	0 16458	0 01742
75	0 112	0 4059	0 15	0 091	0 7589	0 174	0 1474	0 02604
90	0 089	0 429	0 112	0 082	0 712	0 184	0 1431	0 0109
105	0 056	0·48	0 077	0 069	0 682	0 189	0 1484	0 0406

TABLE 3

Changes in amount of proteins in different extracts from 100 g of soil

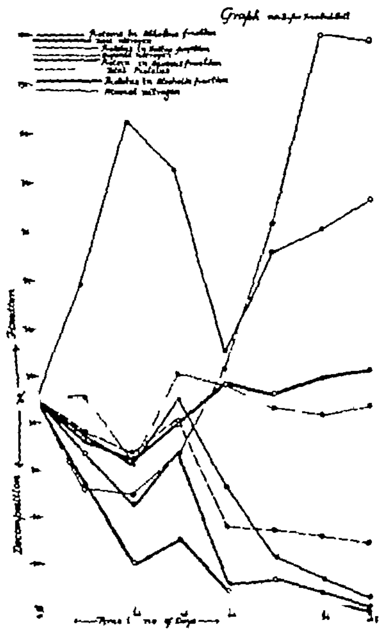
Time in No. of days	Weight in gms. in aqueous extract	Weight in gms. in saline extract	Weight in gms. in alkaline extract	Weight in gms. in alcoholic extract	Total	Total nitrogen	Organic nitrogen	Mineral nitrogen
0	0·241	0·058	0·295	0·258	0·852	0·063	0·03127	0·08773
103	0·13	0·185	0·162	0·075	0·332	0·083	0·0712	0·0118

TABLE 4

Changes in pH value during humification

Time in No. of days	Organic Matter	Treated soil	Soil
0	6 4	8 5	8 6
15	6 9	8 4	8 7
30	7 [illegible]	7 8	8 9
45	8 0	7 1	8 4
60	8 3	8 2	7 9
75	8 4	8 2	7 9
90	8 1	8 1	8 4
105	7 8	8 1	8 9


GRAPH
Organic nitrogen
Total nitrogen
Decomposition
Time in no of Days


Graph
Decomposition ← % → Formation
Time in no. of days

MORPHOLOGICAL STUDIES IN THE ORDER UMBELLALES UMBELLIFERAE I PSAMMOGETON BITERNATUM EDGEW

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Introduction

Umbelliferae displays several interesting morphological features like the secretory ducts variation in inflorescence, stylopodium and carpophore. On account of this it has received considerable attention from morphologists and embryologists. Beghtel (1925) in *Pastinaca sativa* and Borthwick et al (1931) in *Daucus* have described the development of floral parts. In the former the floral primordia arise in succession as petals stamens and carpels while in the latter sepals, petals and stamens come out simultaneously followed by that of the carpel. Rendle (1938) is of the opinion that in most of the umbelliferous plants the stamens appear first, followed by petals and finally the sepals.

Jackson (1933) concluded from her studies on the anatomy of the flower of the Umbelliferae, that the carpophore is axial at the base, while the rest of it is truly carpellary in nature. Further she has reported complete absence of the central bundles in *Hydrocotyle* while recently Mittal (1955) in *Hydrocotyle rotundifolia* and *Centella asiatica*, has shown the presence of these bundles.

Schnarf (1931) has reviewed the embryological work on the family Umbelliferae. Various workers have reported the presence of only a single ovule in each carpel while Borthwick (1931) in *Daucus carota* and Hector (1936) in *Pastinaca sativa* have described the initiation of two ovules the lower on of which only develops normally Multiple female archesporial cells have been reported in the members of the family Umbelliferae. Borthwick (1931) in *Daucus carota* on the other hand, has described only on female archesporial cell which directly functions as a megaspore mother cell. The development of the embryo sac has been found after the *P lygonum* type (Schnarf 1931 Borthwick 1931 and Gupta and Kumari 1959) Maheshwari (1948) in *Drusa oppositifolia* on the basis of the observations of Hakånsson (1923) has described the embryo sac development after Drusa type.

The free nuclear endosperm in *Coriandrum sativum* shows the development of enucleate cytoplasmic nodules (Singh & Gupta 1956) Recently Gupta and Kumari (1959) have also reported the formation of these nodules in *Foeniculum* and *Coriandrum*. Souèges (1940) has described the embryo development in the family Umbelliferae after Solanad type Adventive embryos have also been reported in *Foeniculum vulgare* (Hakånsson 1923)

Material and Methods

The material of *Pseudomogeton biternatum Edgew* fixed in formalin-aceto-alcohol and preserved in 70 % alcohol was dehydrated through alcohol xylol series and embedded in paraffin. Transverse and longitudinal sections were cut at 8-14 μ thickness and stained with Hematoxylin and Crystal violet and Erythrosin.

Observations

Psammogeton biternatum Edgew., is a small xerophytic, pubescent annual herb whose tap root penetrates deep in the sandy soil The leaves are uni-or bi pinnate segments of lower leaves are ovate pinnatifid. The flowers are borne in terminal compound umbels with linear involucral bracts and small lanceol ate involucels The sepals are rudimentary represented as a rim on the top of the ovary surrounding the petals and the stamens The petals are white or purple in colour Gynoecium is bicarpellary and syncarpous. The ovary is inferior and bears two ovules in each loculus of which only one develops to maturity The fruit is ridged and primary and secondary ridges are covered with hooked unicellular hairs.

The vascular supply of the umbellet and the flower

The stalk of the umbellet contains five or six well developed vascular bundles. These bundles, near the base of the flower expand laterally and fuse to form a complete ring of the vascular tissue leaving only a narrow pith in the cetre (Figs. 1 2) Soon this vascular ring gives out five or six traces correspond ing to the number of involucel bracts (Fig 3) Each trace prior to entering the bract produces two lateral branches one on its either side The three traces traversing the involucel bract reach only up to its middle. The remaining vascular tissue in the centre soon splits up into as many groups as the number of the pedicels in the umbellet. Each of these traces divides to form two bundles which supply the pedicel of the flower (Figs. 4 5)

At the base of the flower ten traces arise from the vascular bundles of the ped cel and a group of four poorly differentiated strands is left in the centre During the upward course these come closer and form a compact rod like structure the carpophore of the mature fruit (Fig 6) The ten peripheral bundles supplying the ovary wall are distributed equally in both the carpels and are always found to traverse through the ridges. Through each of the grooves runs an oil canal while the median septum possesses four central vascular strands as well as four oil canals (Fig 7) The peripheral bundles in the upper part of the ovary give rise to ten vascular traces for floral appendages. The traces pass out and supply the petals and stamens in an alternate manner (Figs. 8 9)

Simultaneously th four central strands become more conspicuous and join laterally to form two bundles which are in ·ersely oriented. Near the ovule

bearing region, all four bundles of the ovary wall lying near the septum, ramify and meet the central bundles (Fig 10) The ovular supply arises from the fused products of these bundles and the abortive ovules receive only poorly developed traces. The peripheral bundles (Fig 11) on reaching the stylopodium expand, fuse and organise into six bundles three of which enter each style (Fig 12)

Microsporogenesis

Three or four archesporial cells differentiate in the hypodermis of each lobe of the anther as seen in a cross section. A median longitudinal section however shows a single row of seven or eight cells of hypodermal archesporium (Figs 13 14) A periclinal division of these cells leads to the formation of a primary parietal layer and a primary sporogenous layer (Fig 15) The cells of the parietal layer undergo both periclinal and anticlinal divisions which differentiate into an endothecium, a middle layer and a tapetum (Figs. 16 17)

When anther is mature, the epidermal cells develop the cuticular thickening on the tangential walls and become stretched and flattened. The cells of the second layer the endothecium, are persistent and thick walled while the middle layer gets crushed before the anther reaches maturity The inner most layer is the tapetum. Its cells are binucleate and glandular in nature (Fig 18) Towards the close of the meiotic division in the microspore mother cells or later the tapetal cells become loose, their nuclei start degenerating and finally they are completely absorbed.

The primary sporogenous layer undergoes some divisions to form a mass of microspore mother cells. As a result of meiotic division each of these cells becomes tetranucleate. Cytokinesis by furrowing results in the formation of tetrahedral and isobilateral tetrads (Figs. 19 20) Pollen grains are tricolpate with three germ pores.

Megasporogenesis and the development of female gametophyte

The ovules are orthotropous to start with but finally they become anatropous and pendulous These are unitegmic with a massive integument. The integumentary primordium arises in level with the middle part of the female archesporium. It grows rapidly and surrounds the nucellus forming a narrow and long micropylar canal which is in communication with the micropylar chamber (Fig 21) The inner most integumentary layer forms the integumentary tapetum. The cells of this layer are radially elongated and contain dense cytoplasm.

A single hypodermal archesporial cell is differentiated in the nucellus which is tenuinucellate (Fig 22) It functions directly as megaspore mother cell and divides to form a dyad The second division of the dyad results in the formation of linear tetrad (Figs 23 24) The upper three megaspores of the tetrad degenerate while chalazal one develops further (Fig 25) Three successive

divisions of the functional megaspore nucleus ultimately form an eigth nucleate embryo sac (Figs. 26-28) Simultaneously the nucellar epidermis gets disorganised and the embryo sac comes in direct contact with integumentary tapetum The eight nucleate embryo sac soon starts organisation into an egg apparatus, two polar nuclei and three ephimeral antipodal cells (Fig 29) The cells of the egg apparatus are somewhat pear shaped and tapering towards the micropyle

Endosperm

The primary endosperm nucleus undergoes free nuclear divisions. A large number of nuclei are formed lining up the embryo sac wall and leaving a prominent vacuole in the centre. The number of endosperm nuclei in the micropylar part appears to be slightly larger than those of the chalazal region (Fig 30) The development of endosperm is accompanied by an enlargement of the embryo sac in all directions, more so along the long axis, until the embryo sac becomes more or less semilunar in shape. A number of cytoplasmic nodules or vesicles develop in the micropylar part of the endosperm (Figs 31 32) These are enucleate and are fewer in number in the beginning As the primary nodules fuse with each other the secondary ones are developed on them and thus whole of the central space of the embryo sac is filled w th the cytoplasm of the endosperm. Wall formation in the endosperm progresses from the micropylar end towards the chalazal end till the whole of the endosperm becomes cellular (Fig 33)

Fruit and seed

The fruit i a cremocarp with five primary and four secondary ridges as well as six oil canal in each of the two carpels. A cross section of the mature fruit shows a single outer most layer of epidermal cells The outer wall of this cell layer is well cutinised with long unicellular hooked hairs. The pericarp of the fruit is divisible into two zones—the outer mesophyllous and the inner paren hymatous (Figs. 34 35) The development of the seed follows the compression of the oil canals which are tran versely septate and lined by dark stained ells.

The seed is l gl tly con a e on the inner surface and i albuminous with oily endosperm (Fig 36) Almost the whole space of the seed is occupied by the endosperm for the embryo is minute occupying a sm ll portion in the micropylar end (Fig 36) From all des the endosperm is covered by a layer of seed coat which deri ed from the ep dermis of the integument (Fig 37)

DISCUSSION

The members of the family Umbelliferae w th four central strands in the carpellary region f the flower are more primitive than those in whi h the e strand are either red ced or are totally lacking (Jackson 1933) In *I ton biternatum* Edgew., each carpel has seven bun lles four f which ar l one dorsal and two central. These central bundles are ery m ich

and inversely oriented and, therefore these are the ventral bundles of the carpel which have become variously modified in the development of the carpophore.

As the stylopodium, in almost all umbellifers is differentiated after all floral appendages have become separate it should be a carpellary structure The question, supplying all or fewer carpellary bundles is not of much significance. Although Henslow (1991) on the basis of the continuity of the placental bundles in the stylopodium has regarded it as carpellary in nature it would have been better to consider it as the sterile region of the ovary which has retained the placental bundles In *Psammogeton biternatum* Edgew on the other hand, the stylopodium does not receive these bundles. Thus the organ under discussion is no doubt carpellary but it cannot be considered the sterile region of the ovary The interpretation of the disc as carpellary in *Centella asiatica* by Mittal (1955) does not seem to be convincing as he has shown that the differentiation of the disc takes place before the separation of floral appendages. The disc in *Centella asiatica* up to the region of the floral appendages is partly appendicular and partly carpellary while beyond that it is truly carpellary

The differentiation of only one female archesporial cell directly functioning as megaspore mother cell is a feature of advance nature for in other plants of the family a multiple archesporium is reported The occurrence of cytoplasmic nodules in the free nuclear endosperm of *Psammogeton biternatum Edgew* is interesting Farooq (1953) has reported in *Oldenlandia corymbosa* that the cytoplasmic nodules become detached from the cytoplasm and ultimately degener te Neither Singh and Gupta (1956) in *Coriandrum sativum*, nor the present author in *Psammogeton biternatum Edgew* has observed any detachment of the nodules In these cases after the primary protuberances have fused together other secondary protuberances arise on them By the repetition of this process a num ber of times the whole of space in the embryo sac is filled up with the cytoplasm of endosperm.

SUMMARY

Flowers borne in compound umbels are pentamerous with inferior ovary Vascular supply of stalk of an umbllet consists of five or six vascular bundles Pedicel of flower receives two bundles which split up into ten traces leaving only four strands in the centre. Ten traces from peripheral bundles supply petals and stamens alternately The ovules receive their supply from fusion products of lateral and ventral bundles. All residual bundles except the six which enter styles, gradually disappear in stylopodium.

Microsporogenesis is normal and both isobilateral and tetrahedral tetrads are formed. Pollen grains are tri-colpate with three germ pores Ovules are unitegmic anatropous and pendulous. Development of female gametophyte follows Polygonum type Enucleate cytoplasmic nodules are formed in free nuclear endosperm. Fruit is cremocarp with five primary and four secondary ridges covered with unicellular hooked hairs. Pericarp consists of mesophyll and parenchymatous zones Seed coat is single layered and is [illegible] epidermis of integument.

Acknowledgement

I owe a high debt of gratitude to Dr S P Singh for constant guidance and to Dr Bahadur Singh for valuable criticism and going through the manuscript. I am also grateful to Sri S N Chaturvedi for kindly passing on to me the fixed material and to Dr R K. Singh, Principal B R College, Agra for facilities and encouragement.

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Explanation of Figures

Abbreviations. b, bract; c, carpophore; cb, central bundles; cn, cytoplasmic nodules; epid rmis en, endothecium; end endosperm; oc, oil canal; t, ovular trace; m, middl layer; pr primary ridge; pt, trace for the petal; S sporogenous cells sc, seedcoat sr secondary ridge; st, trace for the stamen; t, tapetum.

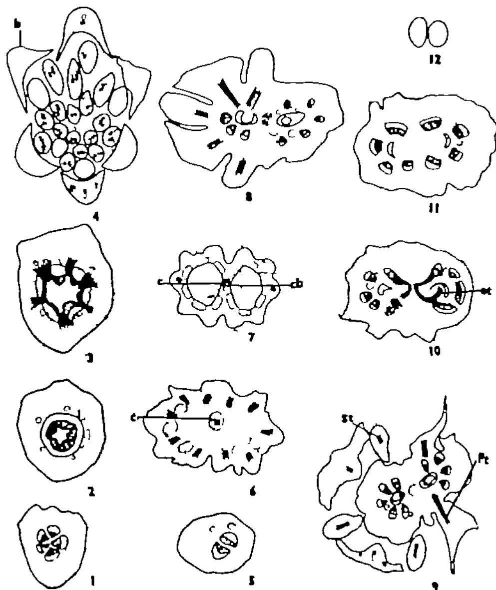
Figs. 1 & 2. Stalk of the umbellet in crossection at different levels. 91 Fig 3. T S. t the base of the umbellet showing origin of al traces for involucels. x 91 Fig 4 T S of he umbellet showing six bracts and several pedicels of the flowers. x 91 Fig 5 Transection of the pedicel of the flower 91 Fig 6. T S. of flower showing ten peripheral traces. x246. Fig 7 T S. of ovary with four central bundles in the septum x91 Figs. 8 & 9 T.S of the ovary showing the origin of traces for petals and tamens. 246. Fig 10. T S of the ovary showing the origin of ovular traces. x 246. Fig 11 T S of ovary at still higher level with residual peripheral vascular bundles x 246. Fig 12 T S of the styles. 220

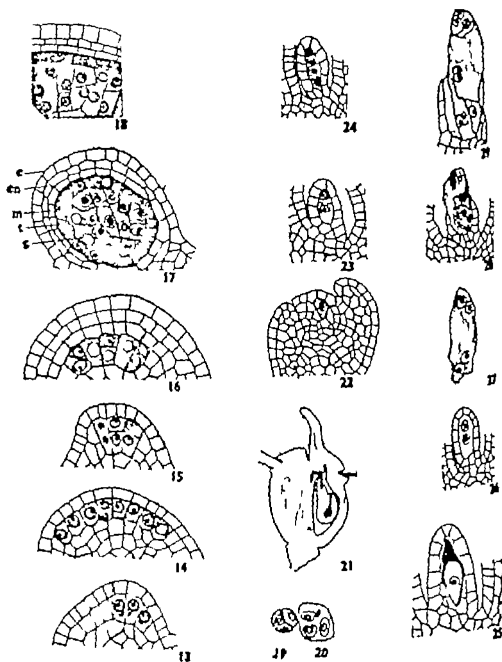
Fig 13 T S. of young anther showing three archesporial cells. 2000. Fig 14 L. S. of th same showing singl row of archesporial cell 1825. Fig 15. T S. of anther showing periclinal divisions in the archesporial cells. 2000 Fig. 16. T S of anther showing two wall layers. 1825 Fig 17 T S of a anther t later tage with four wall layers and a mass of sporogenous tissue x 1825. Fig 18. L. S of anther showing binucleate cells of the

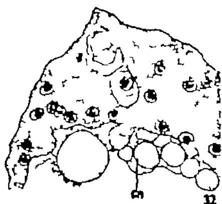
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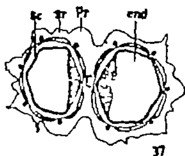
tapetum. x 1825. Figs. 19 & 20. Tetrahedral and isobilateral tetrads. x 2433 Fig. 21 L. S of gynoecium showing functional ovule. x 148. Fig. 22. L. S. of ovule showing single celled archesporium. x 1400. Fig 23 L. S. of ovule with dyad. x 1400. Fig. 24 L. S. of ovule showing linear tetrads. x 1400. Fig 25 L. S. of ovule showing functional megaspore x 1825 Figs. 26-29 Development of embryosac.

Fig.30. Free nuclear endosperm. x 220. Fig. 31 Wall formation in the endosperm and cytoplasmic nodules in the upper half of the endosperm. x 760. Fig 32 Free nuclear endosperm with cytoplasmic nodules. x 1825 Fig. 33. Cellular endosperm with four celled proembryo. x 760. Fig 34 Fruit wall in T S. t premature stage x 680 Fig. 35. Fruit wall of mature fruit. x 680 Fig 36 L. S. of seed with minute embryo t the micropylar end. 94 Fig. 37 T S. of fruit showing primary and secondary ridges. x 94

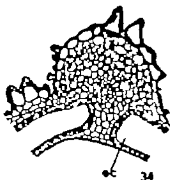



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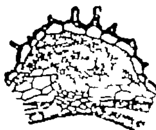

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VOLUMETRIC DETERMINATION OF POTASSIUM PERSULPHATE AND POTASSIUM PERMANGANATE IN A MIXTURE

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Several methods have been described for the estimation of persulphate in aqueous solution, these are volumetric determinations by means of oxalic acid and ferrous sulphate (1) a rapid volumetric method by Bisht and Srivastav (2) and an iodometric method for macro and micro determination by Frigerio (3)

None of the above methods are applicable for the volumetric determination of potassium persulphate in the presence of another oxidising agent. The method of Bertlett and Cotmann (4) for the estimation of persulphate in the presence of organic acids, modified by Saxena & Singhal (5) can be used for the determination of persulphate and permanganate in the mixture of the two with slight modifications.

The author has found that potassium permanganate and potassium persulphate can be correctly determined in a mixture of the two by the method described in the paper

EXPERIMENTAL

Following solutions prepared in double distilled water from chemicals of A. R. quality were used in this investigation (i) N/10 potassium permanganate (ii) N/10 potassium persulphate (iii) N/10 oxalic acid (iv) N/10 sodium thiosulphate (v) 15 N sulphuric acid (vi) N sulphuric acid (vii) 1% manganous sulphate (viii) 1% Starch solution (ix) 4% sodium bicarbonate (x) 40% Potassium iodide.

The solution of potassium persulphate was freshly prepared every day in double distilled water

PROCEDURE

The total amounts of potassium persulphate and potassium permanganate in the mixture were estimated as follows

A mixture containing different ratios of persulphate and permanganate was taken in a 250 ml. pyrex conical flask, and 1·0 ml. of N sulphuric acid, 5·0 ml. of 4% sodium bicarbonate and 5·0 ml. of 40% potassium iodide were added to it. The flask was then kept in dark for half an hour and afterwords 10·0 ml. of N sulphuric acid were added to it and the contents

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(2) A pair of mandibles.
(3) A pair of maxillae.
(4) An unpaired labium.

Labrum: (Fig 1) The labrum in Chilomenes sexmaculata forms the anterior or upper lip of the preoral (extra oral) cavity It is a roughly tripezium shaped yellowish plate twice as broad as long Its maximum breadth from side to side is 0·5 mm. and length 0.25 mm. anteroposteriorly Its anterior surface is richly clothed with a variety of structures. A large number of pits are sparsely scattered all over the general surface. Bristles are symmetrically arranged on the right and left half of the labrum. The anterior margin is provided with 8 pairs of bristles in which the third is the smallest, second slightly elongated while the Vth is stoutest and longest. Rest of the pairs are subequal and sufficiently enlarged. The marginal bristles are followed by five large bristles irregularly arranged in each half of this sclarite, and interspersed by several minute setae. Three small bristles are placed mesially along the anterior margin. Bristles appear to be set within the pits. The margin of the labrum is somewhat highly chitinised in comparison to the labrum proper On either posterior—lateral angle of the labrum the labro-clypeal suture is provided with highly chitinous hook shaped structures called tormae for the purpose of providing insertion.

MUSCULATURE OF THE LABRUM (Fig 2)

1 *The extrinsic muscles of the labrum*—The extrinsic musculature of the labrum consist of a single pair of muscles. They take their origin from the frons and are inserted at the basal angles of the tormae of the labrum The insertion of these muscles confirms Das's (1937) generalization that the lateral muscles are always inserted on the tormae. The contraction of these muscles depresses to the labrum ensuring probably a firmer grip of the prey on which the insect feeds.

MANDIBLES (Fig 3)

The mandibles are the strongest of the mouth parts because these are very heavily chitinized pale yellow conical tructures with round apex curved inwards ending in a pa r of prominent incisor teeth. The base of the mandible is subtriangular measuring 0.375 mm long and 0.29 mm. broad. The outer lateral margin between two angles of this triangular possesses a condyle at each angle and articulates with the gena by geno-mandibulator suture. While the third angle of this base lying adjacent to the oral opening is directed inward These condyles are fitted into alternative cavities in the margin of th gena and acts as efficient hinges for the movement of the mand ble. The ventrally d sposed condyle is much larger and stronger than dorsal one Close to the inner angle of the base there are two pointed basal teeth o molar teeth. In contradistinct on with the observations in Coccinella septempunctata Pradhan (1938) in this insect

both the basal teeth are of equal size and arranged nearly at the same level A little distal to the ventral basal teeth is lodged inwardly the frail chitinous prostheca (prs.) fringed mesially with very minute bristles There hardly exists any difference in the incisors of both mandibles There are numerous pits on the outer half surface of the mandibles but condyle teeth, outer margin and prostheca are devoid of these structures The condyle provides for the insertion of stout tendon of the abductor muscle while the adductor is inserted on the inward angle of the base of the mandible

MUSCULATURE OF MANDIBLES (Fig 4)

The mandible is provided with the following extrinsic muscles only *viz* —

2 *Adductor Muscle*—The large stout and powerful mandibular adductor muscle arising from the postero lateral margins of the cranial wall and running anteriorly converge to form a large tendon which is inserted on the inner angles at the base of mandible Its contraction brings about the two mandibles together and serves to crush and grind the food

3 *Abductor muscle*—It also originates from the cranium a little antero lateral to the adductor and is inserted on the outer side of the basal tringle *i. e* between the condyles of the mandible Th contraction of these muscles pulls the mandible apart.

In a position of rest the abductors are kept contracted and adductors relaxed resulting in a wider gape of the mouth specially the two mandibles

MAXILLAE (Figs. 5 6)

The maxilla of Chilomenes sexmaculata consist of the usual components *viz* —

(1) Cardo—(ca)
(2) Stipes—(st)
(3) Lacinia—(lc)
(4) Galea—(ga)
(5) Maxillary palp

Cardo looks like a ring with broad ventral walls but narrowed dorsally It is fitted into a shallow depression on either side of the labium There are three pointed apodemes on the proximal rim of the cardo. These apodemes project into the head capsule two of them are directed inwards (mesially) while the third one which is the longest, is directed outwards These apodemes provide for the insertion of muscles Distal end of the cardo is connected with the stipital portion of the maxilla The cardo is pr ded with x large bristles in two rows—one lodged t the outer margin and th other mesially Nine small bristles are located irregularly on the mesial aspect along with five or six pits.

The stipital portion is a hollowed structure fitted upon the distal margin of the cardo. The stipes consist of three separate sclerites, the dorso-lateral sclerite (dl) the ventro-lateral sclerite (vl) and ventromesial sclerite (sg). The Stipes has five large bristles on the outer proximal margin and seven such bristles are irregularly placed along with numerous pits and some small bristles inwards. Four large bristles are prominently held out on the ventro-lateral angle of the stipes.

The lacinia arises from the dorsomesial side of the stipes. Lacinia is hollow and sabre shaped. It is clothed with seven large bristles in the proximal row, five such bristles in the middle and four in the distal row. A large number of long and fine setae form the fringe on the distal margin.

The galea arises from the distal margin of the stipes ventral to lacinia. It consist of two segments the proximal segment is small and tubular in structure while the distal segment is large and some what semicircular in shape. A large number of long and fine setae form the fringe on the inner margin similar to Lacinia. Four large bristles are placed on the outer distal margin and a good number scattered all over the ventral surface.

The maxillary palp arises from the latero distal margin of the stipes. It consist of four segments whose size progressively increases towards distally the terminal being the largest. The first segment of maxillary palp is devoid of any sensilla or exoskeleton but the second segment has five large bristles on the outer margin and four on the inner with few sparsely scattered on the general surface along with few pits. The penultimate segment of the palp has four bristles on the outer margin and three on inner with a few sparsely scattered on the general surface. The number of pits is very much reduced. The terminal segment of the palp has eleven large bristles on the outer margin and four such bristles on the inner margin with numerous sparsely scattered on the general surface along with numerous pits.

MUSCULATURE OF MAXILLA (Figs. 7, 8, 9)

The extrinsic muscles of maxilla—There are five muscles which move the maxilla as a whole. Three of them are inserted on long sclerotized hook shaped apodemes of the Cardo and two on the stipital portion. These muscles are described as follows —

4. *Dorsal flexor muscle of the maxilla*. This muscle arises partly from the lateral margin of the foramen magnum and partly from the posterior arm of the tentorium and is inserted on the dorsal apodeme of the cardo.

5. *Ventral flexor muscle of the maxilla*—It arises from the posterior arm of tentorium and inserted on the ventral apodeme of cardo.

6. *Extensor muscle of the maxilla*—This muscle takes its origin from the lateral wall of the cranium and is inserted on the longest apodeme of the cardo.

7 *Extensor muscle of the lacinia*—This muscle arises partly from the posterior arm of the tentorium and partly from the margin of the foramen magnum and is inserted on a long process arising from the outer angle of the base of lacinia. Contraction of this muscle brings about only deflexion of the lacinia and not its flexion Snodgrass (1935) and Das (1937) did not describe any muscle under this name but observed by Pradhan (1938)

8 *Flexor muscle of Subgalea*—This muscle takes its origin from the ventro-lateral margin of the foramen magnum and is inserted on the proximal corner of subgalea, *i e.*, on the ventro mesial sclerite of the stipital portion. Snodgrass (1935) and Das (1937) did not mention any muscle under this designation but noticed by Pradhan (1938)

The intrinsic muscles of maxilla

9 *Subgalear flexor muscle of the galea*—This muscle takes its origin from the mesial margin of the subgalea and is inserted on the base of the distal segment of the galea. Das (1937) describe this muscle as cranial flexor of the galea in the case of musculature of insects larvae.

10 *Stipital flexor muscle of Subgalea*—This muscle originates from two separate places *i. e* along the small lengths of the mesial margin of both the anterior (dorsal) and posterior (ventral) walls of the stipes and are inserted on the mesial margin of the sub-galea.

11 *Stipital muscle of maxillary palpus*—This muscle originates from the median basal part of the stipes and is inserted on the proximal margin of the basal segment of the palpus. According to Pradhan (1938) this muscle acts as levator and depressor simultaneously because the muscle fibres of both the actions are mixed up in it and there is no clear distinction between the fibres. The various movement of the palpus are brought about by contraction of certain fibres and relaxation by others.

12. *Proximal segmental flexor muscle of the palpus*—The fibres of this muscle take their origin from the second segment of the palpus and inserted on the third segment.

13 *Distal segmental flexor muscle of palpus*—This muscle is an exact replica of the proximal segmental flexor arising from the third segment and is inserted on the fourth or the last segment.

LABIUM (Figs. 10 11)

The labium is very simple in structure The prementum (prmt) is a hollow more or less triangular in structure with a pair of labial palpi There are no separate glossae and paraglossae The dorsal inner flap of the prementum is membranous and forms the ventral lip of the preoral cavity The lip is the only representative of ligula Proximally the ventral (outer) chitinised flap is continued downwards into a pair of curved chitinous processes which meet in the middle line. Each maxillary palp is

three jointed the proximal joint is the smallest The prementum is provided with five bristles in two rows the distal having two bristles medially while proximal with three bristles Six bristles—two large and four subequal—are sparsely scattered on the surface along with few pits Distal margin is richly clothed with fine setae There are five bristles on the outer margin and two bristles on the inner margin of the labial palp

There is a very wide membranous area between the prementum and post mentum *This membranous area allows a considerable flexion of the* prementum upwards

The postmentum consists of two distinct plates. The distal plate is called the mentum (mt) and the proximal one the submentum (smt) The mentum is well cl itinised plate and very slightly moveable on the submentum provided with four large bristles two bristles placed laterally on either side along with numerous pits Its sides are curved upwards. The submentum is rigidly fixed to the median sclerotized plate extending between it and the foramed magnum. On its lateral side there occur slight depressions in which cardo of the maxilla articulates. There are no bristle or setae on the surface of the submentum but numerous pits are present.

MUSCULATURE OF THE LABIUM (Fig 12)

Ther are no extrinsi muscle in the labium of Chilomenes sexmaculata.

The intrinsic muscles of the labium—There are two types of intrinsic muscles found in the labium.

14 *Muscles of the prementum*—These mu cles arises from a median fragma on the ba e of the post mentum or submentum and are inserted ventrally on the ba e of the prementum These muscles serve as retractors of the pre mentum. The etraction is possible only due to the presence of a wide membra e between the prementum and mentum

15 *Muscles of the labial palp*—Muscles originating from the proximal sclerotized od of th prementum and inserted on the base of palpi and impart movement to the palpi

DISCUSSION

The nsect under the present study is a Carnivor and preys upon various species of Aphids The morphological structure of mouth parts bears an important elationsl ip with the variety of food.

Th labrum i provided with a pair of extrinsic muscles inserted on the tormae the contracti n of these muscles depresses the labrum which ensures a firm grip of th prey on which these insect feed

The mandibles are the most imp rtant of the mouth parts to provide mechanical mean f treatment of the food. They are provided with a pair of pointed incisor teeth nd a pair of basal teeth in this genus. Pradhan (1938) in

case of Coccinella septempunctata described a pair of pointed incisor teeth and a pair of basal teeth while Saxena (1953) in Luciola gorhami described only a single sharp pointed tooth in the mandible and Sethi (1962) in Scarites indus observed two teeth in the right and three teeth in the left mandible. It, therefore, appears that there is a reduct on in the number of incisor and molar teeth in Carnivorous insects in comparison with Phytophagous one in which apparently a large number of ncisor and molar teeth are required for scraping and masticating the plant tissues It is probably due to the same reason that teeth in Carnivora are large and pointed in comparison to those n Phytophagous insects Larger teeth are intended to bite and cut the prey into pieces while the small ones facilitate the act of scraping and mastication or plant tissues in herbivorous insects. This results in the reduction of incisors and molar teeth in number but grows in size. Consequently the muscles which operate the movement of the mandibles are large stout and powerful in carnivorous insects because they are responsible for seizing and crushing a struggling prey

The prostheca fringed with numerous bristles appears to act as a sensory organ to exercise a discrimination on the food.

In maxilla, the galea acts as a chief sensory organ because it is clothed with numerous bristles and setae but it is comparatively smaller than the galea of phytophagous insects At the time of picking the prey the galea comes in direct contact with the food so that the insect could not feed upon any undesirable prey Its nerve supply supports this view

In labium the prementum is comparatively larger and more expended in this form The presence of a membranous connection between the prementum and post mentum of the labium is very special and unique in this insect. When the insect picks up the prey the labrum depresses downwards by the contraction of its muscles, at the same time the membranous connection present between the prementum and postmentum allows the prementum to be inflected upwards to hold the prey between the labrum and labium, till the prey is not crushed by the mandibles.

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FIG 1

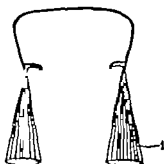


FIG 2



FIG 3

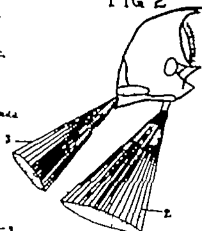


FIG 4

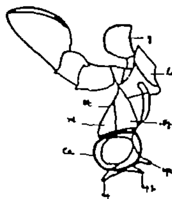


FIG 5



FIG 6

EXPLANATION OF FIGURES

Fig. 1 Dorsal view of Labrum

Fig. 2. Musculature of Labrum.

Fig. 3. Ventral view of Mandible.

Fig 4 Musculature of Mandible

Fig. 5 Ventral view of Maxilla

Fig. 6. Chaetotaxy of Maxilla.

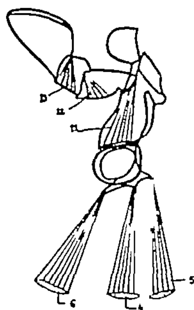


FIG 7

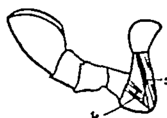


FIG 9

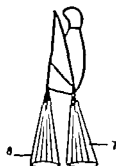


FIG 8



FIG 10

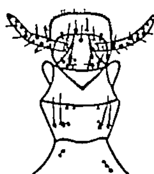


FIG 11

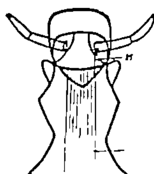


FIG 12

Explanation of Figures

- Fig. 7 Musculature of Maxilla.
- Fig. 8. Musculature of Maxilla.
- Fig. 9 Musculature of Maxilla.
- Fig. 10 Ventral view of Labium.
- Fig. 11 Chaetotaxy of Labium.
- Fig. 12. Musculature of Labium.

FEEDING APPENDAGES AND THE ALIMENTARY CANAL OF *TALITRUS SALTATOR* MONTAGU

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INTRODUCTION

Talitrus saltator Montagu belongs to the sub-order Gammaridea, family Talitridae of the order Amphipoda. A full grown specimen of *Talitrus* is about 20-25 mm long and is brownish grey in colour It is abundantly found along high water mark in sand, associated with rotting sea weed or other debris which preclude the evaporation of moisture. During summer *Talitrus* burrows into sand to a depth of 2 or 3 inches until moist conditions are found It is one of the amphipods who has forsaken sea for land and the animal may be found several miles away from water

Spence Bate and Westwood (1856) Sars (1895) Chevreux and Fage (1925) and Reid (1947) have described the external characters as well as the distribution of the amphipod in different localities of the European coast. However nobody has so far described in detail the feeding mechanism, feeding appendages and the alimentary canal of any of the amphipods. In this account an attempt has been made to correlate these different aspects with respect to *Talitrus saltator*

MATERIAL AND METHODS

Talitrus saltator which are found in abundance under the wooden planks and stones often far removed from the sea, were collected in large numbers from Whitstable on the north Kent Coast (Newell, 1954)

The feeding appendages of the animal were dissected out under stereoscopic microscope. For the immediate study temporary glycerine preparations were examined. For detailed study the appendages after being treated with a dilute solution of potassium hydroxide were mounted in canada balsam. Another method of making permanent preparation of mouth parts, where in the different appendages were directly mounted in a mixture of polyvenyl lactophenol and indigo carmine was found to be more useful the camera lucida diagrams were drawn from these preparations. To study the arrangement of the mouth parts, the narcotised animals were studied the horizontal sections of the head also gave an idea of the arrangement of the mouth parts. To examine the mouth parts in action, living specimens were constantly observed under the stereoscopic microscope during the act of feeding.

The stained preparations of the young specimens, gave an idea of the general plan of the allimentary canal. The internal structure of the gut was examined by cutting longitudinal and horizontal sections of the anterior part of the animal. For the critical study of the alimentary canal as a whole and to find out the position of the different parts of the gut with respect to the body segments, serial transverse sections of the animal were cut. An out line diagram of the animal was first drawn on a sheet of graph with the help of the squared eye piece. The same animal was then cut in transverse sections of 8 microns thickness. The whole series of sections after making the necessary calculations were carefully set on the predrawn diagram of the animal thus presenting a diagrammatic view of the longitudinal section of the animal. The camera lucida diagrams of some of the sections were also drawn.

The different fixatives tried include Duboscq Brasil Zenker Gilson's fixative Gatenby's Flemming without acetic (Gatenby 1937) Mann's mixture of equal parts of a 1% osmic acid solution and 5% sublimate solution and a mixture as follows absolute alcohol 70% 90 parts glacial acetic acid 3 parts, formol 40% 7 parts. The animal in each case was narcotised in ether before it was fixed. Both Cellodin paraffin as well as paraffin methods were used for embedding (Carleton 1938). Different stains such as Mallory's triple stain Heidenhain's Azan stain Mann's methyl blue eosin and Heidenhain's iron alum haematoxylin counter stained with eosin or orange G were employed. This last one was found to be most useful

FEEDING APPENDAGES

In the feeding appendages of *Talitrus* are included the different mouth parts and the two pairs of antennae which help as accessory appendages during the feeding mechanism.

The superior antenna of amphipods in general consists of a three jointed peduncle or protopodite and a long flexible many jointed flagellum or endopodite. In addition a short accessory flagellum or exopodite may also be present at the junction of the peduncle and the flagellum. In *Talitrus* the superior antenna (Plate I S Ant.) is very small and rudimentary. The peduncle is quite large its basal joint being especially well developed while the flagellum is very small and has only five segments. The accessory flagellum is altogether absent. Both peduncle as well as flagellum are provided with small thick spines on both sides.

The inferior antenna of *Talitrus* is exceptionally large (I Ant.) and consists of a very large peduncle and a large many jointed flagellum. The peduncle is longer than the flagellum and appears to consist of only three articulations, the two basal ones being fused into the frontal wall of the head. The olfactory denticle is wanting. The organs of smell probably undergoes some change to meet the altered condition of the existence of the animal

from that of the marine crustaceans in general The inferior antenna of male is much longer sometimes 2/3 the length of the animal while it is much shorter in the female.

Paired jaws or mandibles of an amphipod consist of a strong protopodite including a masticatory part or cutting edge and a molar expansion Each mandible usually has a three jointed palp or endopodite. However the palp is absent in the mandible of *Talitrus* (Mand.) The mandibles are very strongly built so as to crush the larger food particles on which the animal feeds. These powerful organs are armed at the biting edge with teeth, formed more for tearing than for cutting below which a second row of denticles is fixed upon a plate which is movable. The molar expansion (M E.) of the mandible is especially well developed and forms a prominent oval bulging with its outer edge strongly serrated A few long spines curved inwards and a large number of fine feathered spines are present in between the incisors and molar expansion. The molar expansion or grinding tubercle at its inner base is crowned by very minute denticles and corresponds with similar grinders on the opposite jaw By the joint action of these two molar tubercles an imperfect mastication is effected

First pair of maxillae form the second series of mouth parts of an amphipod. Each maxilla is usually tri partite; the protopodite consists of an inner basal lobe and an outer masticatory lobe which may bear a jointed endopodite or palp The first maxilla of *Talitrus* (F Max.) is also very strong and aids in the trituration of food Its basal lobe (B. L.) is very small and bears only two large spines. The masticatory part of the first maxilla is very large its inner portion (M L.) bears a large number of fine spines on its inner margin and a pair of long barbed spines distally while its outer part (P) has a few incurved tooth-like projections distally These projections bear nodule-like outgrowths on their inner margins.

The second maxilla (S Max.) consists of two flat lobes of which the inner one (I L.) the protopodite is a little smaller than the outer endopodite (O L.) Both the lobes are produced distally into long spines. The spines of the outer lobe are much better developed.

The two maxillipeds (M. Pd.) of either side are fused by their protopodites so as to form a sort of lip of the buccal mass. The protopodite consists of a large well developed inner basal lobe (B. L.) and poorly developed masticatory lobe (M L.) The basal lobe has a few fine feathered spines and a few simple ones towards its inner and distal borders The masticatory lobe has on its inner margin a few well developed tooth-like spines. The long endopodite or palp is even jointed the inner margin of the distal joint is produced into a large number of small spines. The outer margin of the palp as a whole is also clothed with a few simple spines especially at the joints of their articulations.

caecum which extends anteriorly above the stomach and ends blindly almost opposite the mouth (Fig L. S Ant. Reg D Ca.)

A pair of wide pouches (Fig 9 V Ca) arise from the antero-ventral margins of the midgut which extend backward as paired tubular ventral caeca on the two sides of the midgut From the floor of the midgut in this region arises a small caecal ridge (Fig 9 C.A) The vent al hepato-pancreatic caeca run backwards as a pair of tubes upto the middle of the third thoracic segment, where they divide into two pairs of ventral caeca (Fig 10 V Ca.) which run as far back as the fourth abdom nal segment when they end blindly

From the dorsal margin of the midgut in the region of the second abdominal segment arise a pair of posterio dorsal caeca which immediately divide into two pairs of narrow tubes (Fig 11 P D Ca) whi h extend for wards upto the first abdominal segment A pai of these caeca also extend backwards beyond their origin upto the end of the fifth abdominal segment when they bend dorsally to run a short distance forwards before they end blindly (Fig L. S. Post Reg., P D Ca.)

The small hindgut or rectum of *Talitrus* is confined to the last three segments of the animal. It is lined internally with a thick cuticle The epitl elial lining of the rectum is raised into a large number of well developed villi In the region of the third abdominal segment, a prominent typhlosole-like projection hangs down from the dorsal margin so as to occupy abo t half of the lumen (Fig 13) In the region of the fifth abdominal segment the internal cuticular lining of the rectum is produced into a large number of small spine like projections F gures 15 & 16) Here the internal l nin is produced into a pair of dorsal and a sm ll ventral ingrowth so that the lumen of the rectum appears to be triangular n transverse section. In the la t portion of the rectum, the internal wall becomes greatly thickened and on oluted, these folds are especially prom nent dorsally where the lumen of the rectum is almost completely obliterated Ult ma dorso-ventrally longated rectum opens to the exterior by a narrow ve Fig 19 An.)

DISCUSSION

It is ell e tabl lied fact that the natu e of the and the cha r f structure concerned with the captu r sortin of f l e elated to th kind of food and to whether o n st t is l uspension Authors like Yonge (1927) have examined rustace n feed from tl correlation of t u ture and function

The ch acte of the feeding ap e pected to be related to the character o ter of the food, three d fferent aspect are t t i predominan tl animal or plant (tl It follows a conti uous or discontinuous patt

It has been found that *Talitrus* commonly feeds on algal filaments and other vegetable matter although it occasionally feeds on animal diet as well According to Bate (1857) it has been seen feeding on a common earthworm or even on mammal remains when they can find nothing else, they content to feed on each other He also described that a handkerchief which a lady let fall among them was soon reduced to a piece of open work by jaws of the creatures. As to the size of the food of *Talitrus* it is mainly macrophagous, commonly feeding on large pieces of *Ulva* and *Fucus* which they hold firmly with the help of the maxillipeds, the first two pairs of gnathopods and the second pair of antennae. The strong incisors of mandibles chew it into small pieces the process is supplemented by the grinding process of the molar expansion of the mandibles These small crushed particles of food are then passed into the mouth, the long second pair of antennae help in forcing the food through the mouth.

It, therefore, implies that in the macrophagous and vegetable feeding forms like *Talitrus*, the antennae, maxillipeds and anterior gnathopods are adopted for holding the food. The powerful mandibles and maxilla are seen to be engaged in rapid action of biting and mastication of the food particles. The palps of the mandibles and maxillae, in the macrophagous forms can hardly be of direct use and are therefore absent.

Before discussing the correlation between the gut organisation and the feeding habit of the animal, it is necessary to recall the functions of the different parts of the alimentary canal Huxley (1880) described the cardiac stomach of Crayfish as a food crushing region where the food is reduced to pulpy state, while the pyloric stomach works as a strainer Ide (1892) also points to the masticatory function of the cardiac stomach and filtering mechanism of the pyloric stomach. According to Gelderd (1907) the different plates of th cardiac stomach work as auxilliaries to the mandibles The pyloric stomach serves for the mixing up of the already masticated food with the different ferments. Tait (1917) was of the opinion that the foregut is merely a propelling organ and has nothing to do with the mastication of food. Nicholls (1931) also considered that the *stomach of Ligia is not concerned with the* mastication of food.

However the author is convinced that in the case of *Talitrus* the cardiac stomach is mainly concerned with the mastication of food the different plates or ridges fringed with spines, teeth, hooks etc. are adopted for its trituration The armature of the pyloric stomach with clusters of fine bristles seem to work as a strainer A few specimens when fed on carmine particles and a few others on iron saccharate clearly showed that the larger particles are present in the cardiac stomach and in the upper chamber of the pyloric stomach while only finer particles are able to pass into the lower chamber of the pyloric stomach where, as in the case of *Orchestia* (Agrawal 1963) it comes in contact with the digestive enzymes secreted by the ventral hepato-pancreatic caeca

These investigations point to the conclusion that in the macrophagous forms like *Talitrus* the cardiac stomach has a strong armature to masticate the larger food particles the pyloric stomach with its fine bristles serves as a filter apparatus and also mixes food with the digestive enzymes. The food then passes into the midgut where as also found in *Corophium* (Agrawal, 1963) it is digested and absorbed.

SUMMARY

Talitrus saltator Montagu is abundantly found along high water mark in sand during summer it burrows into sand to a depth of 2 to 3 inches.

It is macrophagous in feeding habit and commonly feeds on algal filaments and other vegetable matter

The feeding appendages of *Talitrus* include two pairs of antennae, a pair of mandibles two pairs of maxillae, a pair of maxillipeds and an upper and a lower lip. The antennae help in catching and holding the food while the strongly armed mandibles and maxillae masticate the large food particles on which it feeds.

The alimentary canal of the animal consists of the foregut (oesophagus and stomach) midgut (intestine) and hindgut (rectum) The cardiac stomach is provided with a large number of ridges which are armed with spines hooks or teeth and serves for further mastication of the food particles. The inner wall of the pyloric stomach is produced into long bristles and thus serves as a filtering apparatus so that only finer particles of food are transmitted into the midgut

The midgut gives out a number of pyloric caeca, the most important of which are two pairs of ventral hepato-pancreatic caeca which secrete the different digestive enzymes The food is digested and absorbed in the midgut

The inner wall of the rectum is produced into a large number of complicated folds. It finally opens to the exterior by a narrow ventral anus.

ACKNOWLEDGEMENT

I am thankful to Prof J E Smith F R S., of London University under whose supervision this work was conducted.

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Plate I Showing feeding appendages of Talitrus saltator
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Abbreviations Used

A., Anus; A.Lip, Anterior lip; B, Body B.L. Basal lobe; B.P Basal part C.A. & Ca.A., Caecal ridge; D.A., Dorsal ridge; D.Ca., Dorsal caeca D.L., Dorso-lateral ridge FL, Flagellum; F Max. First maxilla I Ant., Inferior antenna; I L., Inner lobe; L H Lateral horn; L.L., Latero-lateral ridge; Mand Mandible M.E. Molar expansion; M. G Midgut M.L., Masticatory lobe; M P Masticatory part; M Pd., Maxilliped; M.V.P Mid-ventral piece; Oe Oesophagus Oe.A., Oesophageal ridge; O.L., Outer lobe P Outer part f masticatory lobe; P D Ca., Posterior dorsal caeca; Py G Pyloric groove Ped. Peduncle; P Lip. Posterior lip S Ant. Superior antenna S Max., Second maxilla; St., Stomach V.A., Ventral ridge V.Ca., Ventral caeca; V.L., Ventro-lateral ridge

These investigations point to the conclusion that in the macrophagous forms, like *Talitrus* the cardiac stomach has a strong armature to masticate the larger food particles the pyloric stomach with its fine bristles serves as a filter apparatus and also mixes food with the digestive enzymes The food then passes into the midgut where, as also found in *Corophium* (Agrawal, 1963) it is digested and absorbed.

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PLATE I

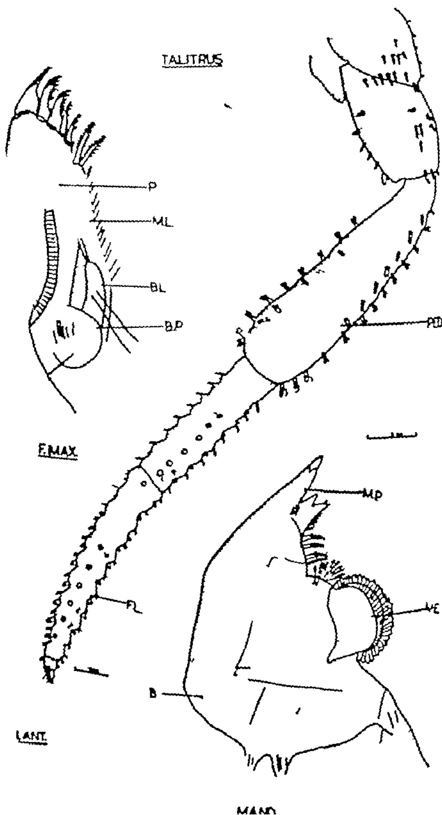


PLATE II

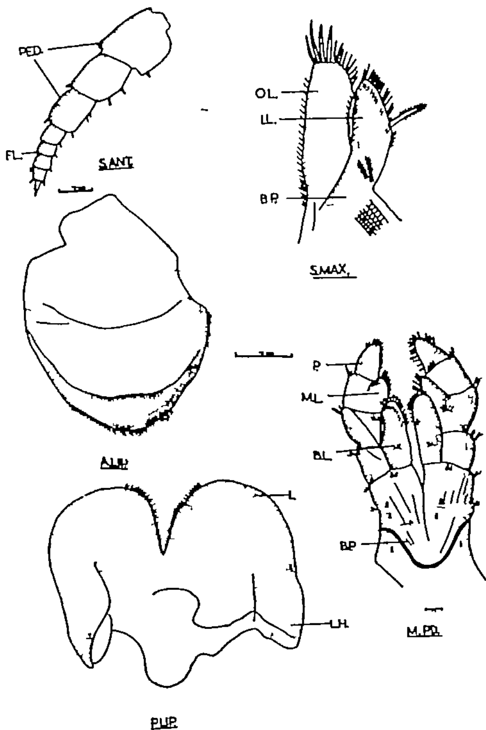
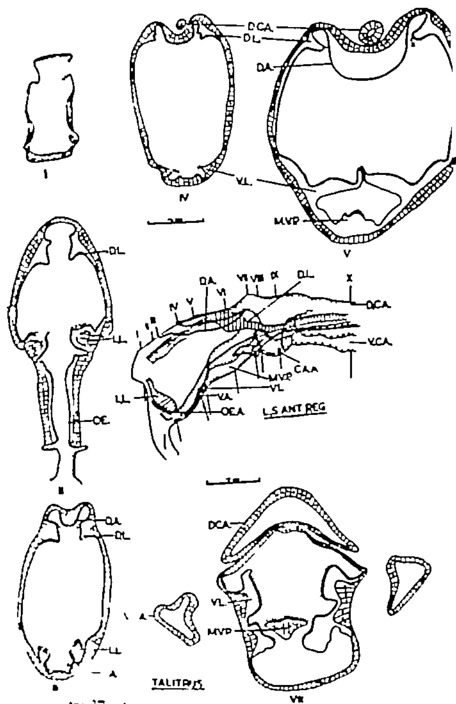


PLATE III



D.C.A.
D.L.
D.A.
V.L.
M.V.P.
I
IV
V
D.L.
L.L.
OE.
II
D.A.
VII VIII
IX
D.L.
X
IV
V
VI
D.C.A.
V.C.A.
C.A.A.
M.V.P.
V.L.
V.A.
L.L.
OE.A.
L.S ANT REG
D.A.
D.L.
L.L.
A.
DCA.
VL.
MVP.
TALITRUS
VII

PLATE IV

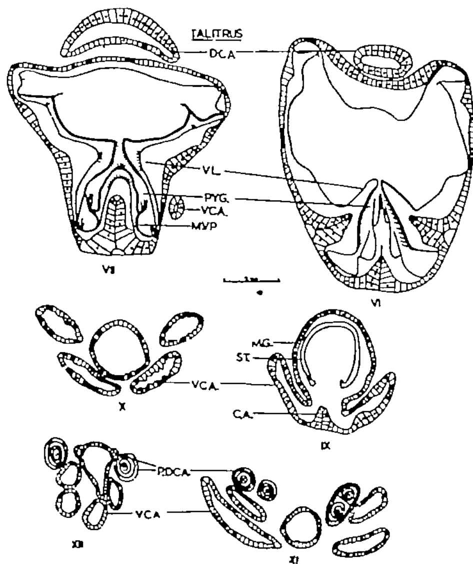
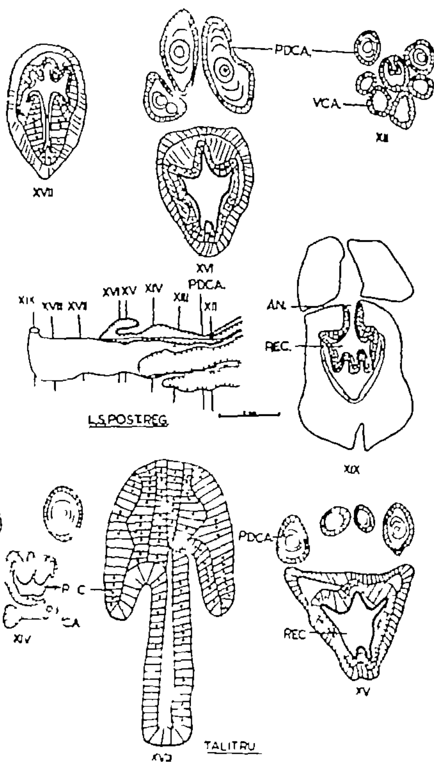

TALITRUS
D.C.A.
VL
PYG.
VCA.
MVP
VII
VI
MG.
ST.
VCA.
C.A.
X
IX
P.D.C.A.
VCA
XII
XI

PLATE V


PDCA.
VCA.
XII
XVII
XVI
XIX
XVII
XVI
XVI XV
XIV
PDCA.
XIII
XII
AN.
REC.
L.S.POST.REG.
XIX
PDCA.
P C
XIV
REC.
XV
TALITRU

A STUDY ON VARIABILITY IN THE QUALITY OF WOOL ON DIFFERENT REGIONS OF THE FLEECE OF *MAGRA SHEEP*

J P SINGH, G S SINGH* AND S N SINGH
Department of Animal Husbandry & Dairying B R. College Agra

India has 40.3 million heads of sheep which yield about 72 million lb of raw wool (Wool News, 1962) We have monopoly of producing carpet quality in the world and almost 50 per cent of the total wool yield is exported. Annually we earn foreign exchange worth Rs. 8 crores through this source.

The sheep which produce the superior carpet wool *i.e.* *Bikaneri* wool' are the *Magra* *Marwari*, *Chokla* and *Puggal* breeds of Rajasthan (Narayan 1955) Among all *Magra* tops the list.

The present Government policy for the improvement of the sheep and wool industry in the plains is to produce *Bikaneri* wool' by introducing *Magra* blood by selective breeding in Rajasthan and by crossing with local breed in other states. As such on an average annually about 5 lacs of *Magra* sheep are transported (Narayan 1956) from Bikaner to U P M.P A. P., Madras etc. The improvement by selection and crossing will be judged by studying the wool characteristics which are not similar all over the fleece A suitabl sampling region has to be located for routine comparison which might reasonably speak for the fleece. In addition to it, during skirting and grading processes, the knowledge of wool quality at different regions of a fleece is very essential f a successful wool industry With these objects in view an experiment was designed to study the wool characteristics on different regions of the *Magra* fleece in both the sexes.

EXPERIMENTAL TECHNIQUE

For the proposed investigation, 10 male and 20 female *Magra* sheep of similar age and body weight were selected as the experimental subject. The animals were maintained on the same plane of nutrition throughout the experimental period The sheep were shorn thrice a year at quarterly intervals in the middle of March, July and November 1961 *Samples from* spring (15th March) and *Monsoon* (15th July) clips were only incorporated in the pre ent investigation.

Sampling Technique

The entire fleece was divided into 6 regions, *viz.*, neck, shoulder middle britch loin and wither (Plate I) For each region samples were collected from 4 sq inch tatooed area as shown by dotted line in the same plate. Wool wa clipped by a small scissor as close to the skin as poss ble. The

Sheep \ trition ~A. R.)

samples so obtained from each region were separately kept into small numbered paper bags for study of the following wool characteristics

(1) Staple length
(2) Staple crimp
(3) Proportion of different types of fibres
(4) Fibre length
(5) Fineness at the point on the staple about half an inch from the butt end, and
(6) Medullation at the same point on the staple as in (5) above.

Analytical Technique

Staple length—Five staples were selected at random from collected wool samples for each region The staple was not stretched but pressed gently along the scale on the valvet board. It was measured from butt end to the tip where most of the fibres terminate. The length was recorded in centimeter

Staple crimp—The number of crimps from butt to tip end was counted a crimp comprising half curved and half tuft portion Total number of crimps was divided by the staple length and crimp content per inch length was calculated

Proportion of different types of fibres—The purity was determined by dipping the individual fibre in benzene. Forty fibres from each five staples were drawn by the forcep In all 200 fibres were tested. Benzene was taken in a petri-dish and fibres were dipped individually The fibres completely invisible in benzene were considered pure, partly visible and partly invisible as hetero and completely visible as hair After separating into different types they were counted and the percentage of each type was calculated

Fibre length and diameter—The length and diameter of fibre were estimated by the procedures recommended by Indian Standards Institute New Delhi during the years 1959 and 1955 respectively There was some modification in the diameter determination technique. Sections of petrol washed staples were cut with the help of Hardy s Sectioning device. The diameter was measured by a Lanameter type MP3 varimex projection microscope.

Medullation—Alongwith diameter percentage of the different types of medullated fibres was also recorded. On the basis of the extent of medullation the fibres can be classified as under —

Superfine (Plate II)	Non-medullated.
Traces (Plate III)	Interrupted Medullation or in traces.
Fine (Plate IV)	Medullation to the extent of less than 25% of total diameter
Medium (Plate V)	Medullation to the extent of 25-50% of total diameter
Coarse (Plate VI)	Medullation to the extent of 50-75% of total diameter
Widely latticed (Plate VII)	Medullation to the extent of more than 75% of total diameter

After recording each type of medullation total percentage of medullated fibres was calculated.

Results and Discussion

For judging the quality of wool fibre from different regions of the fleece staple length, staple crimp, fibre length, diameter medullation, purity and modes of medullation of each sample were estimated. The entire study has been discussed as under —

I Study on the Wool Characters—Length, Crimp Diameter and Medullation

(a) *Variation in wool characters due to fleece regions*

The average values with their standard error for the different wool characters of the wool samples collected from the six regions of 20 ram and 40 ewe fleeces during the two seasons have been estimated and compiled in table 1

The data were statistically analysed and the critical differences for each region at 5 and 1 per cent probability have also been given in the same table.

TABLE 1

Average values of the mean staple length, crimps fibre length diameter and medullation for each region alongwith their critical differences.

Regions	Staple length (cm.)	No. of crimps/inch of staple length	Fibre length (cm.)	Diameter in micron	Medullation (per cent)
Neck	5 88±0 06	2 72±0 11	9 31±0 07	34 65±0 24	37 60±1 40
Shoulder	5 29±0 03	2 74±0 06	8 31±0 06	34 68±0 15	39 70±1 70
Side	5 51±0 04	2 24±0 01	7 54±0 08	34 84±0 17	38 02±1 60
Britch	5 13±0 03	2 18±0 01	7 85±0 08	36 15±0 34	45 97±3 10
Loin	5 85±0 04	2 31±0 05	9 35±0 06	34 85±0 22	36 69±1 00
Wither	6 64±0 05	2 41±0 05	10 19±0 06	33 19±0 18	36 86±1 10
Average	71	2 44	8 76	34 73	39 14
Critical Difference					
P<0·05	0 58	0 69	0 79	0 84	20 62
P<0·01	0 77	0 98	1 05	1 4	27 29

(i) *Staple length*—The averages of the mean values of staple length for each region (Table 1) varied from 3 13 to 6.61 cm. The wither samples were longest followed by neck loin side shoulder and britch (Plate VIII) Sunnanda (1951) and Bruen *et al* (1931) have also observed the regional variation for staple length with *Pattanwadi* and *Deccan* sheep respectively The former has noted the greatest staple length on neck. Similar observations have al o been reported by Lockart (1954) with Merino sheep The analysis of variance for staple length measurements has been presented in table 2.

TABLE 2

Analysis of variance of the mean values of staple length.

Sources of variation	d. f	S S	M S S	F Value
Total	359	3411 32		
Between region (R)	5	71 76	14 35	*3 1
Between Sex (S)	1	1614 34	1614 34	*357 81
Region x Sex	5	10 92	2 18	0 47
Error	318	1684 3	4 6	

* Significant (P<0·01)

The analysis of variance (Table 2) shows that the variation due to regi ons s sign ficant at 1 per cent probabil ty The critical difference (Table 1) hows that there is a significant difference (P ∠ 0 01) between the average values of d fferent regions within three groups (1) wither (2) Neck and loin and (3) shoulder and brit h. The value of each region with n group 2 nd 3 d es not d ffer significantly The average value of side region (5 51 cm.) d es n t d ffer signifi antly from any region in group 2 and 3 but it differs gn i l (P ∠ 0 01) as ompared to that of wither sample The difference n r ce values of the houlder sample and to that of neck and loin n s t nt only per ent level of p obability whereas, from wither sample t iffers even t 1 per ent probability As su h it will be convenient to d nd d ff nt parts on the bas s of average staple length—(1) wither 2) ne k nd loin (3 side nd 4) houlder and britch.

Th gr t differen es between w ther and br t h samples may be due t th n nt we ng f the br t h w ol again t the floor and grasses dur ing normal l b ne t It ma als be nfluenced by some environmental factors

(ii) C mp The number of imps nch of taple length was highest in shoulder sampl f llowed b ne k w ther l n de and br tch (Table I)

On the basis of present investigation, they can be grouped as—(1) shoulder and neck, (2) loin and wither and (3) side and britch. The analysis of variance for the crimp's data has been given in table 3

TABLE 3

Analysis of variance of the mean values of number of crimps/inch of staple length.

Sources of variation	d. f	S S	M S. S	F Value
Total	359	1187 7		
Between region (R)	5	72 5	14 5	0 32
Between Sex (S)	1	238 9	238 9	*5 32
Region × Sex	5	57 5	11 5	0 26
Error	348	1562 8	44 9	

*(Significant (P<0 05)

It may be seen from table 3 that there is no significant region-differences in crimp content per inch of staple length.

(iii) *Fibre length*—The average values of fibre length varied from 7.5 to 10 19 cm. (Table 1) The greatest fibre length has been found to be on wither followed by loin, neck, shoulder britch and side. The data for the average values of the means have been statistically analysed. The analysis of variance has been recorded in table 4

TABLE 4

Analysis of variance of the mean values of fibre length.

Sources of variation	d f.	S S.	M S. S	F Value
Total	359	4552 6	..	..
Between egion (R)	5	284 0	56 8	*10 81
Between Sex (S)	1	2405 1	2405 1	458 10
Region × Sex	5	36 7	7 3	1 39
Error	348	1826 8	5 25	

**Significant (P<0·01)

(i) *Staple length*—The averages of the mean values of staple length for each region (Table 1) varied from 5 13 to 6 64 cm The wither samples were longest followed by neck, loin side, shoulder and britch (Plate VIII) Sunnanda (1951) and Bruen *et al* (1941) have also observed the regional variation for staple length with *Pattanwadi* and *Deccan* sheep respectively The former has noted the greatest staple length on neck. Similar observations have also been reported by Lockart (1954) with Merino sheep The analysis of variance for staple length measurements has been presented in table 2.

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Error	348	1684 3	4 6	

**Significant (P<0·01)

The analysis of variance (Table 2) shows that the variation due to regions is significant at 1 per cent probability The critical difference (Table 1) shows that there is a significant difference (P ∠ 0 01) between the average values of different regions within three groups *viz.*, (1) wither (2) Neck and loin and (3) shoulder and britch. The value of each region within group and 3 does not differ significantly The average value of side region (5.51 cm.) does not differ significantly from any region in group 2 and 3 but it differs significantly (P ∠ 0 01) as compared to that of wither sample. The difference in average values of the shoulder sample and to that of neck and loin is significant only at 5 per cent level of probability whereas, from wither sample it differs even at 1 per cent probability As such it will be convenient to divide a fleece into 4 parts on the basis of average staple length —(1) wither (2) neck and loin (3) side and (4) shoulder and britch.

The great differences between wither and britch samples may be due to the constant wearing of the britch wool against the floor and grasses during normal daily routine life It may also be nfluenced by some environmental factors.

(ii) *Crimps*—The number of crimps/inch of staple length was highest in shoulder sample followed by neck, wither loin side and britch (Table 1)

On the basis of present investigation, they can be grouped as—(1) shoulder and neck, (2) loin and wither and (3) side and britch. The analysis of variance for the crimp s data has been given in table 3

TABLE 3

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Sources of variation	d. f	S S	M. S S.	'F' Value
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Between Sex (S)	1	238 9	238 9	*5 32
Region × Sex	5	57 3	11 5	0 26
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*(Significant (P<0 05)

It may be seen from table 3 that there is no significant region-differences in crimp content per inch of staple length.

(iii) *Fibre length*—The average values of fibre length varied from 7.5 to 10 19 cm. (Table 1) The greatest fibre length has been found to be on wither followed by loin neck, shoulder britch and side. The data for the average values of the means have been statistically analysed The analysis of variance has been recorded in table 4

TABLE 4

Analysis of variance of the mean values of fibre length.

Sources of variation	d f	S S	M. S. S.	F' Value
Total	359	4552 6		
Between region (R)	5	284 0	56 8	10 81
Between Sex (S)	1	2405 1	2405 1	458 10
Region × Sex	5	36 7	7 3	1 39
Error	348	1826 8	5 25	

*Significant (P<0·01)

The analysis of variance (Table 4) shows that variation in fibre length due to region is significant at 1% probability The critical difference (Table 1) shows that on the basis of significant difference the regions may be divided into 4 groups—(1) wither (2) neck and loin (3) shoulder and (4) side and britch. The group 2 sample significantly differs from groups 3 and 4 at 5 per cent and 1 per cent probability respectively The difference between groups 3 and 4 is significant only at 5 per cent probability while within groups 2 and 4 the difference is found to be insignificant.

Similar observations have also been recorded on *Deccan* and *Pattanwadi* sheep by Bruen *et al.*, (loc. cit.) and Sunnanda (loc. cit.) Bruen *et al.*, also noticed the maximum length at wither Although Sunnanda has reported the maximum fibre length in neck region but the difference between neck and wither was insignificant.

(iv) *Fibre diameter*—The average value of the fibre diameter (Table 1) varied from 33 19 to 36 15 micron in different regions of the fleece. The finest fibres have been found in wither region followed by neck, shoulder side loin and britch. The data have been statistically analysed to judge the significance of different values The relevant figures for the analysis of variance has been recorded in table 5

TABLE 5

Analysis of variance of the mean values of fibre diameter

Sources of variation	d. f.	S S	M S. S	F Value
Total	359	49155 0		
Between region	5	267 0	53 4	*3 02
Between Sex	1	42402 0	42402 0	**2396 8
Region × Sex	5	327 0	65 4	**3 70
Error	348	6159 0	17 7	

*Significant (P<0 05)
*Significant (P<0·01)

The analysis of variance (Table 5) indicates that the variation in the fibre diameter due to region is significant at 5 per cent probability On the basis of variation (Table 1) the regions may be divided into 3 groups—(1) wither (2) neck, shoulder side a d loin and (3) britch. The difference between group 1 and the rest is significant at 1 per cent probability The neck and shoulder samples differ from britch at 1 per cent whereas side and loin at 5 per cent level of probability The differences in regions within group 2 were insignificant.

When the diameter of *Magra* breed fibre with that of *Pattanwadi* sheep (Sunnanda, loc cit.) is compared it is found that *Magra* breed carries comparatively finer wool at all regions. Bedreldin *et al* (1952) support the present findings that shoulder region possesses finer wool than hip region Results that britch region contains comparatively coarser fibres are in agreement with that of Renner and Swart (1929)

(v) *Medullation*—The average values of the medullated fibres in each region of the fleece (Table 1) varied from 34 69 to 45 97 per cent. The extent of medullation has been recorded to be 2 00 to 85 41 per cent. The loin region has been found to contain least medullated fibres followed by wither neck, side shoulder and britch. The data have been statistically analysed and the analysis of variance is given in table 6

TABLE 6

Analysis of variance of the mean values of medullated fibres

Sources of variation	d. f	S S	M. S. S	F Value
Total	359	1303541 0		
Between Region	5	4752 9	950 6	0 281
Between Sex	1	117630 .	117630 2	* 34 720
Region × Sex	5	2423 3	484 7	0 143
Error	348	1178734 6	3387 1	

Significant (P<0 01)

It may be seen from table 6 that the variation in the medullation percentage of the fibres in different regions of the fleece is insignificant. The britch region contains highest per cent of the medullated fibres as compared to other five regions.

(b) *Variation due to sex*

Irrespective of the regions, the data for staple length, crimp content, fibre length fibre diameter and medullation were sorted out sex-wise. The respective findings for rams and ewes have been given in table 7

of each region due to sex has statistically been found to be insignificant. However the difference in fibre diameter in each region due to sex is significant (Table 5) Sunnanda (loc. cit.) has also made similar observations

2 *Proportion of Different Types of Fibre*

(a) *Variation due to region*

A fleece is composed of different types of fibres such as, pure hetro- and hairy in varying proportion The different types of fibre found in different regions of the fleece were studied and the results irrespective of sex are recorded in table 9

TABLE 9

Mean values of pure hetero- and hairy fibres of wool samples on different regions of a fleece (per cent)

Regions	Pure	Hetero-	Hairy fibres
Neck	22 88±2 50	58 81±4 41	18 33±2 21
Shoulder	18 23±2 12	58 81±4 80	22 96±3 11
Side	24 79±3 01	58 25±5 11	16 96±2 54
Britch	9 45±1 61	59 57±4 22	30 98±2 88
Loin	16 68±3 11	62 08±3 99	19 24±2 71
Wither	23 15±3 45	58 40±5 45	18 45±3 01
Critical Difference			
P<0 05	8 23	3 48	9 38
P<0 01	15 78	7 58	17 89

It will be seen from table 9 that on an average pure, hetero- and hairy fibres varied between 9·45 ± 1·61 and 24 79 ± 3·01 58 25 ± 5 11 and 62·08 ± 3 99 and 16·96 ± 2 54 and 30·98 ± 2 88 per cent respectively The pure fibres are highest in side region followed by wither neck, loin shoulder and britch Hetero-types are highest in loin followed by britch shoulder neck, wither and side. The hairy fibres are highest in britch followed by shoulder loin, wither neck and side.

(b) *Variation due to sex*

Irrespective of the regions the data have been sorted out for rams and ewes separately The average values have been recorded for each wool attribute in table 10

TABLE 10

Average values of pure hetero- and hairy fibres of wool as influenced by sex (per cent)

Types	Ram	Ewe	Critical Difference P<0·05	Critical Difference P<0·01
Pure	16 5°±2 67	23 27±1 98	5 45	0 48
Hetero-	60 04±5 50	58 81±4 99	4 50	8 71
Hairy	23 37±2 78	17 92±1 76	4 78	9 75

The data presented in table 10 indicate that ewes contain comparatively more pure fibre than rams, which in turn carry more hetero-and hairy fibres. The differences in pure and hairy fibres in ram and ewe fleeces are statistically significant at 1 and 5 per cent of probability respectively whereas there is no significant difference in the hetero- type fibres in the two cases.

(c) *Variation due to region × sex*

The average values of different types of fibres in each region as influenced by sex have been recorded in table 11

It may be seen from table 11 that ewes carry more pure wool on the whole fleece as compared to rams. The ewe fleece contains more hetero-type fibre on shoulder side and wither and less on neck, britch and loin than those of rams The hairy fibres are more on all the regions except loin in ram fleeces It shows that except pure fibre there is not a particular trend of variation in the types of fibre on all the regions of the fleece from both the sexes.

3. Study on the Types f Medullated Fibres

(a) *Variation due to region*

The verage values of different types of medullated fibres in the specified regions of the fleece have been calculated and presented in table 12

It will be seen from table 12 that wide latticed-fibres (Plate VII) are highest t britch region (3·91%) followed by loin, side, shoulder neck and wither Coarsely (Plate VI) and medium (Plate V) medullated fibres are also highest in the britch region. For coarse fibres, the decreasing trend is from britch to wither side loin, neck and shoulder and for medium again from britch to w ther loin, neck, shoulder and side. Only finely (Plate IV) and tracely (Plate III) medullated fibres are highest in side and shoulder

TABLE 11

Average values of pure, hetero-and hairy fibres of wool samples as influenced by sex in different regions of the fleece (per cent)

Types	Sex	Neck	Shoulder	Side	Britch	Loin	Wither
Pure	Ram	14 93±1 29	15 14±1 81	20 00±2 10	7 24±0 94	15 87±1 78	23 26±2 18
	Ewe	30 80±2 54	21 31±2 31	29 59±3 14	11 65±2 00	22 74±1 89	[illegible]9 93±2 74
Hetero-	Ram	60 60±3 40	59 50±4 91	58 00±4 79	[illegible]9 91±5 11	66 22±4 89	58 12±4 98
	Ewe	57 01±4 31	60 31±5 12	59 90±4 92	59 58±4 77	57 85±4 99	58 79±4 61
Hairy	Ram	24 47±2 21	25 36±2 10	22 00±1 99	52 85±4 21	17 91±2 10	18 62±1 90
	Ewe	12 19±0 98	18 83±0 99	10 51±1 33	28 77±1 96	19 41±1 21	18 28±1 01

TABLE 12

Types of medullated fibres in different regions of the fleece (per cent)

Types	Neck	Shoulder	Side	Britch	Loin	Wither
Wide latticed	0 98±0 09	1 18±0 11	1 37±0 08	3 91±0 10	1 99±0 21	0 88±0 15
Coarse	4 74±0 50	4 04±0 75	5 63±0 61	9 52±0 81	5 40±0 71	5 79±0 53
Medium	16 95±2 10	15 72±2 07	14 93±1 95	17 91±1 83	16 42±1 28	16 55±1 50
Fine	5 95±0 88	6 88±0 75	6 91±0 99	6 46±1 20	5 31±1 00	5 62±0 88
Traces	8 98±1 50	11 88±1 87	9 18±0 99	8 17±0 89	7 57±0 76	8 02±1 01

regions respectively The decreasing trend for finely medullated fibres is from side to shoulder britch, neck, wither and loin and for tracely medullated from shoulder to side, neck, britch, wither and loin

Variation of the types of medullated fibres does not follow any regular trend. However on the basis of the widely medullated fibres (more than 25 per cent medullation of the entire diameter) the regions may be classed into three groups (1) britch, (2) loin and wither and (3) neck, shoulder and side. It indicates that neck, shoulder and side contain less widely and more thinly as well as tracely medullitated fibres

(b) *Variation due to sex*

Irrespective of regions, variation in the types of medullated fibres due to sex has been calculated and recorded in table 13

TABLE 13

Types of medullated fibres as influenced by sex (per cent)

Types	Ram		Ewe	
Wide-latticed	2 15±0 07	20 25%	0 90±0 03	25 88%
Coarse	5 95±0 04		5 06±0 08	
Medium	12 15±2 17		19 92±2 21	
Fine	5 19±0 75	14 24%	7 34±0 89	17 78%
Traces	9 05±0 95		10 44±1 01	

The data (Table 13) indicate that the fibres with more than 25 per cent medullation of the diameter are more in ewes (25 88%) and less in rams (20·25%) Similarly finely and tracely medullated fibres are also more in ewe fleece (17 78%) than that of rams (14 24 %)

(c) *Variation due to region × sex*

Th data for different types of medullated fibres in each region as influenced by sex have been calculated and their average values have been recorded in table 14

It may be seen f om table 14 that rams in each region carry more wide latticed and coarsely medullated fibres. The finely and tracely medullated fibres are more in ewe fleece as compared to ram on all the regions except neck where rams carry more tracely medullated fibres in comparison to ewes.

TABLE 14

Types of medullated fibres as influenced by sex in different regions of the fleece (per cent)

Types	Sex	Neck	Shoulder	Side	Britch	Loin	Wither
Wide latticed	Ram	1 30±0 06	1 50±0 05	1 33±0 30	4 44±0 02	2 87±0 04	0 51±0 03
	Ewe	0 63±0 01	0 86±0 02	1 41±0 01	1 37±0 02	1 10±0 02	0 25±0 01
Coarse	Ram	6 53±0 08	4 99±0 09	5 72±0 08	7 36±0 07	5 65±0 07	5 94±0 07
	Ewe	2 95±0 01	3 18±0 02	5 73±0 01	7 67±0 02	5 21±0 02	5 63±0 01
Medium	Ram	11 12±2 15	12 14±1 98	11 34±2 26	10 08±1 99	12 42±1 56	15 84±2 18
	Ewe	21 17±3 05	19 30±2 98	18 32±1 78	23 80±2 79	20 41±2 08	17 25±1 99
Fine	Ram	4 63±0 05	5 38±0 06	5 74±0 05	5 79±0 04	5 31±0 05	7 93±0 04
	Ewe	7 27±0 10	8 37±0 09	8 08±0 15	7 12±0 13	5 31±0 14	7 66±0 08
Traces	Ram	10 35±0 99	11 81±0 89	8 71±0 78	10 01±0 68	6 04±0 70	7 66±0 80
	Ewe	9 27±0 25	11 95±0 23	9 65±0 28	14 33±0 27	9 10±0 18	8 38±0 27

It may be mentioned here that widely medullated fibres (more than 25 per cent medullation of the diameter) are found more on rams than on ewes, and the reverse becomes true when thinly medullated fibres (less than 25 per cent medullation of the diameter) are considered.

SUMMARY

In order to study the variation in the wool characteristics on different regions of a fleece, 10 rams and 20 ewes of *Magra* breed were selected. Samples from the tatooed area in each region were collected at the sp ing (1 th March) and *Monsoon* (15th July) clips 1961

Average values of staple length crimp number fibre length diameter and medullation irrespective of the sex for each region show that there is significant difference in staple length fibre length and fibre diameter due to region at 1 per cent probability The differences in crimp number and medullation percentage due to regions have been found to be statistically insignificant.

Differences in staple length fibre length, diameter and medullation due to sex irrespective of the regions have been found to be statistically significant (P<0.01) However difference in the crimp number is significant at 5 per cent probability

A study of interaction of region and sex for different wool characters reveals that difference in staple length crimp number fibre length and medullation in each region due to sex is statistically insignificant. there is a significant difference t 1 per cent probabil ty in fibre on each region due to sex.

A study of the proportion of the different types of fibre was each region irrespective of the sex. Pure wool is maximum (24 79±3.01%) hetero-type fibres on the loin (62.08±3 %) fibres on the britch region (30.98±2 88%)

Variation due to sex in the different types of fibres irrespective region shows that ewe fleece contains more pure fibres (23 27 ram fleece more hetero-(60 04±5.50 %) and hairy fibres (23 5

Variation in the purity of wool fibres due to region and sex been studied. Results indicate that on the whole in each region ewes carry comparatively more pure wool than the rams lar trend for hetero-and hairy fibres on each region due to

A study on the types of medullated fibres found on fleece indicates that on the basis of widely medullated (per cent medullation of the entire diameter) all the regions into three groups—(1) britch, (2) loin and wither and

and side. The shoulder and side regions contain comparatively more finely and tracely medullated fibres.

When we consider the difference in types of medullated fibres due to sex irrespective of regions we find that ewe-fleece contains more medium, finely and tracely medullated fibres (37 70 %) than that of ram fleece (26.59%) The wide latticed, and coarsely medullated fibres are also more in ram fleece.

When one considers the wool attributes of the mid-side region as discussed in the text and also the area represented on the fleece, it becomes obvious that this region is the nearest approach to a representative sample of the fleece as a whole

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PLATE I

Demarkation of the different regions of fleece—1 Neck, 2. Shoulder 3 Side 4 Britch 5 Loin and 6. Wither



PLATE II

Superfine fibre—non-medullated



PLATE III

Tracely and interrupted medullated fibre

(i) Interrupted—right and left fibre.

(ii) Tracely—middle fibre.











PLATE VIII

Comparative staple length for each region—1 Neck, 2. Shoulder 3 Side, 4 Britch, 5 Lion, and 6. Wither

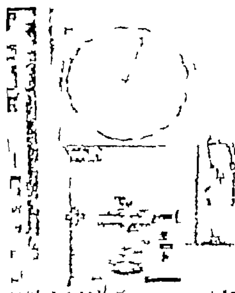


PLATE IV

Fine fibre—medullation to the extent of less than 25% of total diameter



PLATE V

Medium fibre—medullation to the extent of 25-50% of total diameter



PLATE VI

Coarse fibre—medullation to the extent of 50-75% of total diameter



PLATE VII

Wool Latticed fibre—medullation to the extent of more than 75% of total diameter

(a) Wide Latticed—left fibre.

(b) Medium—right fibre.

LINEARIZED TRANS-SONIC CONICAL FLOWS

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SUMMARY

The problem of flow of a compressible fluid past a cone with axis in the direction of the undisturbed stream has been solved by direct integration of the linearized equation both for super-sonic and for sub-sonic flows. Dr M. Ray has made it possible by means of a particular substitution for conical boundaries. In this paper it has been possible by means of a general substitution of which Dr M. Ray's substitution is a particular one.

FORMULATION

To study the problem of aerodynamic phenomena around a body of revolution the axis is assumed coincident with the axis of the body and the y-axis normal to the x-axis in the meridian plane in the direction of the radius of every circular cross-section of the body For the cone let its axis be parallel to the undisturbed flow and let x-axis be taken along it. If V be the velocity of the undisturbed stream in the direction of x-axis, the velocity potential ϕ satisfies the differential equation (Antonio Ferri—1949)[1]

$$(1-M^2)\frac{\partial^2\phi}{\partial x^2}+\frac{\partial^2\phi}{\partial y^2}+\frac{1}{y}\frac{\partial\phi}{\partial y}=0 \tag{1}$$

where M is the Mach number given by

$$M=\frac{v}{a}\text{ (}a=\text{speed of the sound)}$$

The equations of velocity are

$$\frac{\partial\phi}{\partial x}=V+u=V+\frac{\partial\phi_1}{\partial x}\quad \frac{\partial\phi}{\partial y}=v=\frac{\partial\phi_1}{\partial y} \tag{2}$$

where ϕ_1 is the potential function which defines the variation of the flow generated by the presence of the body

Evidently ϕ also satisfies the equation

$$(1-M^2)\frac{\partial^2\phi_1}{\partial x^2}+\frac{\partial^2\phi_1}{\partial y^2}+\frac{1}{y}\frac{\partial\phi_1}{\partial y}=0 \tag{3}$$

Antonio Ferri 1949 and Miles 1950[2] have solved it from the potential of a source (or sink) distribution along the axis of the body the distribution depending on the shape of the body Dr M Ray[3] has solved it by direct integration of the equation (3) by means of a particular substitution. In this

Now this expression will be constant if for some relation in p and n

$$\frac{y^{n}}{x^{1-p}} \text{ and } \frac{y^{n-1}}{x^{-p}}$$

both are constant.

If we take $-p=n-1$ these two expressions become $\left(\frac{y}{x}\right)$ and $\left(\frac{y}{x}\right)^{-1}$

which being functions of $\frac{y}{x}$ are constant.

Again
$$\frac{\partial\phi_1}{\partial y}=ny^{n-1}x^{p}f(\eta)+y^{n}x^{p}f'(\eta)\left(\frac{-Ax}{y^{2}}\right)$$
$$=n\frac{y^{n-1}}{x^{-p}}f(\eta)-\frac{y^{n-2}}{x^{-p-1}}Af'(\eta)$$

This expression will be constant if, for some relation in n and p

$$\frac{y^{n-1}}{x^{-p}} \text{ and } \frac{y^{n-2}}{x^{-p-1}}$$

both are constant.

If we take $-p=n-1$ these two expressions become $\left(\frac{y}{x}\right)^{n-1}$ and $\left(\frac{y}{x}\right)^{n-2}$

which being functions of $\frac{y}{x}$ are constant.

Thus the same relation between p and n that is to say $-p=n-1$ makes $\frac{\partial\phi_1}{\partial x}$ and $\frac{\partial\phi_1}{\partial y}$ both as constant.

Thus the above conditions are satisfied if

$$\phi_1=\frac{y^{p}}{x^{p-1}}f(\eta) \tag{4}$$

and

$$\eta=A\frac{x}{y} \tag{5}$$

A being a constant.

From here

$$\frac{\partial\phi_1}{\partial x}=-(p-1)\frac{y^{p}}{x^{p}}f(\eta)+\frac{y^{p}f'}{x^{p-1}}(\eta)\frac{A}{y}$$
$$=-(p-1)\left(\frac{y}{x}\right)^{p}f+\left(\frac{y}{x}\right)^{p-1}Af'$$
$$=\text{a function of }\left(\frac{y}{x}\right)$$
$$=\text{a constant.}$$
$$\frac{\partial\phi_1}{\partial y}=p\frac{y^{p-1}}{x^{p-1}}f(\eta)+\frac{y^{p}}{x^{p-1}}f'(\eta)\left(-\frac{Ax}{y^{2}}\right)$$
$$=p\left(\frac{y}{x}\right)^{p}f(\eta)-\left(\frac{y}{x}\right)^{p-2}Af'(\eta)$$
$$=\text{a function of }\frac{y}{x}$$
$$=\text{a constant.}$$

SUPERSONIC FLOW

For supersonic flow we have $M>1$ so putting $B^2=M^2-1$ the equation (3) becomes

$$B^2\frac{\partial^2\phi_1}{\partial x^2}=\frac{\partial^2\phi_1}{\partial y^2}+\frac{1}{y}\frac{\partial\phi_1}{\partial y} \tag{6}$$

With the substitution of (4) and ( ) the equation (6) becomes

$$B^2A^2\ [p\ (p-1)\ f-2f'\ (p-1)\ \eta+f''\ \eta^2]$$
$$=p\ (p-1)\eta^2 f-2\ (p-1)\ \eta^3 f'+f''\ \eta^4+pf\eta^2-f'\ \eta^3$$

where dashes denote differentiations of $f\ (\eta)$ with respect to η

Let the constant A be chosen in such a way so that $A=\frac{1}{B}$ Hence $\eta=\frac{x}{By}$

Then the above equation becomes

$$(\eta^2-\eta^4)\ f''+\{(2-2p)\eta+(2p-1)\eta^3\}\ f'+\{p\ (p-1)-p^2\eta^2\}\ f=0 \tag{7}$$

SOLUTION

For the solution of (7) we first consider the particular cases when $p=0$ 1 etc.

Case I If we put $p=0$ in (7) we get

$$f''\ (\eta^2-\eta^4)+f'\ (2\eta-\eta^3)=0$$

i e.,

$$f''\ (\eta-\eta^3)+f'\ (2-\eta^2)\ \ =0$$

This is exactly the same equation as obtained by Dr M. Ray[4] (1950) and its integral is

$$f=-k\left[\ \cosh^{-1}\eta-\frac{(\eta^2-1)^{\frac{1}{2}}}{\eta}\right]$$

where k is a constant, so that

$$\phi_1=-k\left[x\cosh^{-1}\frac{x}{By}-(x^2-B^2y^2)^{\frac{1}{2}}\right]$$

Case II. If we put $p=1$ we get

$$f''\ (\eta^2-\eta^4)+f\ \ \eta^3-\eta^2 f=0$$

or

$$f''+\frac{\eta}{1-\eta^2}\ f'-\frac{1}{1-\eta^2}\ f=0$$

Here $f=\eta$ satisfies it.

Hence its solution is (Byerly[5] 1895)

$$f=\eta\ \left[k_2+k_1\int\frac{\sqrt{\eta^2-1}}{\eta^2}\,d\eta\right]$$
$$=\eta\ \left[k_2+k_1\left\{\cosh^{-1}\eta-\frac{(\eta^2-1)^{\frac{1}{2}}}{\eta}\right\}\right]$$
$$=k_2\ \eta+k_1\left\{\eta\cosh^{-1}\eta-(\eta^2-1)\ \ \right\}$$

$$= k_2 \frac{x}{By} + k_1 \left\{ \frac{x}{By} \cosh^{-1} \frac{x}{By} - \frac{\sqrt{x^2 - B^2 y^2}}{By} \right\}$$

$$\phi_1 = k_2 \frac{x}{B} + k_1 \left\{ \frac{x}{B} \cosh^{-1} \frac{x}{By} - \frac{\sqrt{x^2 - B^2 y^2}}{B} \right\}$$

Applying boundary conditions and writing $\frac{k_1}{B} = -k$

we get

$$\phi_1 = -k \left\{ x \cosh^{-1} \frac{x}{By} - \sqrt{x^2 - B^2 y^2} \right\}$$

This is exactly the same equation as obtained by Dr M. Ray[4] (1950)

Case III Now let p be any number positive or negative integral or fractional.

Let us integrate equation (7) which can be put in the form

$$f'' + \frac{\{(2-2p)\eta + (2p-1)\eta^3\}}{\eta^3 - \eta} f' + \frac{\{p(p-1) - p^2\eta^2\}}{\eta^2 - \eta^4} f = 0 \tag{8}$$

Evidently $f = \eta^p$ is a particular solution of (8)

Then by Byerly's method[5] the solution is

$$f = \eta^p \left\{ k_2 + k_1 \int \frac{e^{-\int P d\eta}}{\eta^{2p}} d\eta \right\} \tag{9}$$

where $$P = \frac{2 - 2p + (2p-1)\eta^2}{\eta - \eta^3}$$

Now $$-\int P d\eta = \log \eta^{2p-2} (\eta^2 - 1)^{\frac{1}{2}}$$

Equation (9) becomes

$$f = \eta^p \left\{ k_2 + k_1 \int \frac{\eta^{2p-2} (\eta^2 - 1)^{\frac{1}{2}}}{\eta^{2p}} d\eta \right\}$$

$$= \eta^p \left\{ k_2 + k_1 \int \frac{(\eta^2 - 1)^{\frac{1}{2}}}{\eta^2} d\eta \right\}$$

$$= \eta^p \left[k_2 + k_1 \left\{ \cosh^{-1} \eta - \frac{(\eta^2 - 1)^{\frac{1}{2}}}{\eta} \right\} \right]$$

$$= \left(\frac{x}{By} \right)^p \left[k_2 + k_1 \left\{ \cosh^{-1} \left(\frac{x}{By} \right) - \frac{(x^2 - B^2 y^2)^{\frac{1}{2}}}{x} \right\} \right]$$

$$\phi = \frac{x}{B^p} \left[k + k_1 \left\{ \cosh^{-1} \left(\frac{x}{By} \right) - \frac{(x^2 - B^2 y^2)^{\frac{1}{2}}}{x} \right\} \right]$$

Applying boundary conditions and writing $\frac{k_1}{B^p} = -k$

we get

$$\phi_1 = -k \left\{ x \cosh^{-1}\frac{x}{By} - (x^2 - B^2y^2)^{\frac{1}{2}} \right\} \tag{10}$$

which is the same result as obtained by Dr M. Ray

SUBSONIC FLOW

For subsonic flow $M<1$ so putting $B^2 = 1 - M^2$ the equation (3) becomes

$$B^2 \frac{\partial^2\phi_1}{\partial x^2} + \frac{\partial^2\phi_1}{\partial y^2} + \frac{1}{y}\frac{\partial\phi_1}{\partial y} = 0 \tag{11}$$

With the substitution (4) and (5) the equation (11) becomes

$$B^2A^2 [p(p-1) f - 2f'(p-1)\eta + f''\eta^2]$$
$$+ p(p-1) f\eta^2 - 2f'(p-1)\eta^3 + f''\eta^4 + pf\eta^2 - f'\eta^3 = 0$$

where dashes denote differentiations with respect to η

Taking $A = \frac{1}{B}$ so that $\eta = \frac{x}{By}$ we get

$$(\eta^2+\eta^4) f'' + f'\{(2-2p)\eta - (2p-1)\eta^3\} + f\{p(p-1) + p^2\eta^2\} = 0 \tag{12}$$

If we put $p=0$ we get

$$f''(\eta+\eta^3) + f'(2+\eta^2) = 0$$

which is exactly the equation (12) of Dr M. Ray

Equation (12) can be put in the form

$$f'' + \frac{\{(2-2p) - (2p-1)\eta^2\}}{\eta+\eta^3} f' + \frac{\{p(p-1)+p^2\eta^2\}}{\eta^2+\eta^4} f = 0 \tag{13}$$

Evidently $f = \eta^p$ is the particular solution of (13)

Hence applying Byerly's method we get

$$f = \eta^p\left[k_2 + k_1\left\{\sinh^{-1}\eta - \frac{(\eta^2+1)^{\frac{1}{2}}}{\eta}\right\}\right]$$

$$= \left(\frac{x}{By}\right)^p \left[k_2 + k_1\left\{\sinh^{-1}\left(\frac{x}{By}\right) - \frac{(x^2+B^2y^2)^{\frac{1}{2}}}{x}\right\}\right]$$

$$\phi_1 = \frac{x}{B^p}\left[k_2 + k_1\left\{\sinh^{-1}\left(\frac{x}{By}\right) - \frac{(x^2+B^2y^2)^{\frac{1}{2}}}{x}\right\}\right]$$

Applying boundary conditions and writing $\frac{k_1}{B^p} = -k$ we get

$$\phi_1 = -k\left[x\sinh^{-1}\left(\frac{x}{By}\right) - (x^2+B^2y^2)^{\frac{1}{2}}\right] \tag{14}$$

which is exactly the equation No. 14 of Dr M Ray

The boundary conditions give

For Supersonic Flow

$$\frac{k}{V}=\frac{\tan\alpha}{(\cot^2\alpha-B^2)^{\frac{1}{2}}+\tan\alpha\cosh^{-1}\left(\frac{\cot\alpha}{B}\right)} \tag{15}$$

where K will be real if cot $\alpha>B$.

For Subsonic Flow

$$\frac{k}{V}=\frac{\tan\alpha}{(\cot^2\alpha+B^2)^{\frac{1}{2}}+\tan\alpha\sinh^{-1}\left(\frac{\cot\alpha}{B}\right)} \tag{16}$$

If $M=0$ or $B=1$ we get from (14)

$$\phi_1=-k\left[x\sinh^{-1}\left(\frac{x}{y}\right)-(x^2+y^2)^{\frac{1}{2}}\right] \tag{17}$$

ACKNOWLEDGEMENT

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SECONDARY GROWTH IN THE DETACHED LEAVES OF *LAGENARIA VULGARIS* SER.

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INTRODUCTION

Various workers from time to time noted root formation in detached leaves when the latter were kept with their petioles dipped in water either without any treatment or after pretreatment with some synthetic hormone. Swingle (1940) and Yarwood (1946) described root formation from the callus tissue formed at the cut end of detached leaves upon culturing the latter in water or on moist sand without any pretreatment with a growth hormone.

Application of hormones in the induction of roots was first reported by Gregory and Samantarai in 1950. Afterwards, Misra and Samantarai (1, ?) showed that hormone treatment induced early root initiation in all the leaves tested by them while in a few cases roots were formed only when they were pretreated with growth hormones. Similar reports came from Samantarai and Misra (1955) Samantarai, Misra and Kabi (1955) Samantarai and Kabi (1954a) and Samantarai and Sinha (1955). However Mitra and Nanda Bose (1957) differed from Samantarai and his coworkers (*loc. cit.*) as they found that pretreatment with hormones activated the formation of roots only in those detached leaves which developed roots without any pretreatment, but could not induce root formation in those species in which roots were not formed in controls. Gupta (1957) on the other hand reported very early root formation in the leaves of *Urtica dioica* even without any pretreatment with auxins.

Activation of cambium in the vascular bundles of the petiole and veins of detached leaves on their culture, has been reported in many cases by Samantarai and Kabi (1954b). In most of these cases first activation of intrafascicular cambium was observed, but with continued culturing of the leaves, interfascicular cambium also got activated. Samantarai and Kabi (1954b) considered that activation of interfascicular cambium was due to the effect of growth hormone while Mitra and Nanda Bose (1957) considered that application of growth hormone did not result into any new histological development but it only enhanced those which were already present in the control leaves. While Samantarai and Kabi (1954b) observed that the secondary growth in the cultured leaves was similar to the stems, such similarity was not reported in *Boerhaavia diffusa* and *Urtica dioica* by Mitra and Nanda Bose (1957) and Gupta (1957) respectively.

In the present work the authors report the root initiation on the detached leaves of *Lagenaria vulgaris* and its effect on the internal an

MATERIALS AND METHODS

Healthy leaves from fourth node down the shoot apex of the plants were cut in water with sharp scalpel First the leaves were washed in running tap water and then placed in Petri-dishes containing either tap or d stilled water These Pet-i-dishes were later arranged in north facing wir dows against diffused light at room temperature (27°—3 C) The water of Petri-dishes was chan ged daily in order to avoid the growth of m cro-organisms. Rooting response was measured by the days taken for the first oot emergence number of roots per leaf and the length of the longest root. Experiments were conducted in the repl cations of three.

Fo anatom cal stud es free hand sections were cut from different places of the cultured leaves at 7 days intervals and compared to those cut from healthy leaves The petioles were cut at three consecutive places *viz.*, at the base the middle and the apex. The sections were stained with safranin and haematoxylin or with safranin and fast green

OBSERVATIONS

Root Formation i Detached Leaves—Detached leaves when kept in tap or distil ed water developed callus at the cut end in -4 days and later a number of roots developed from it in 5-10 days. The detached leaves could be kept in health conditions on tap or distilled water for 4-5 weeks. Experi mental data, as given in table I shows that the days taken for the appear ance of first roots was more in distilled water than in tap water In the latter case the roots developed in 5-6 days while in distilled water t took 7 9 days. Number of roots per leaf and the maximum size of the longest root greatly varied in both tap and distilled water Howe er there was slight indication that the number of roots and the maximum size of the longest oot formed in distilled water was more than thos formed in tap water

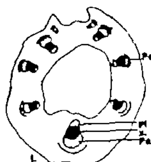
TABLE 1

Root formation in the detached leaves.

S No	Medium in which leaf was kept		Days after which first root ppeared	After 7 days		After 14 days		After 21 days	
				No. of roots	Maximum length of root	No. of roots	Maximum length of root	No. of roots	Maximum length of root
1	Tap W ter		5	5	15 cm	5	20 cm	5	28 cm
		b	5	8	12 cm	6	18 cm	8	23 cm
			6	7	10 cm	7	17 cm	7	20 cm
2	Distilled Water		7	10	20 cm	10	24 cm		
		b	8	5	8 cm	5	17 cm	5	21 cm
			9	6	13 cm	6	22 cm	6	21 cm

Leaf died.

Anatomy of Petiole—Transverse section from base of a petiole of a freshly detached leaf showed a grove on the adaxial side with 9 vascular bundles arranged in a concentric ring around a central cavity Vascular bundles of the adaxial side were smaller m size th in those of the abaxial s de (Fig 1)



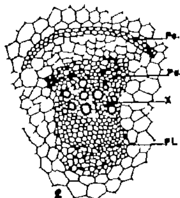
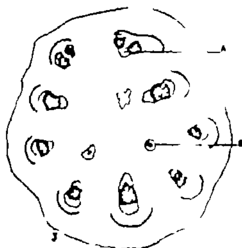


Fig 1 T S from the base of normal leaf (Pe-pericycl Pl-inner phloem, Po-outer phloem X Xylem) X 10

Fig 2 A vascular bundl from Fig 1 showing pericycle (Pe) outer phloem (Po) xylem (X) and inner phloem (Pl) X 50.

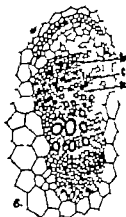
The vascular bundles were bicollateral w th endarch xylem Inne phloem was less developed and the cambium wa not distinct Two layered sclerenchymatous pericycle was found to be present outside each vascular bundle (Fig 2) Secondary growth vas not seen even in the petiole of the oldest leaf taken from the plant (Fig 3) though th outer cambium was distinct in the vascular bundles (Fig 4) However radial spliting of vascular bundles and the formation of new vascular bundles was seen in such cases. The vascular bundles of the adaxal side became clefted by the development of secondary parenchymatous tissue in between the two arms of the xylem (Fig 3-A) Such splitting increased the number of vascular bundles in the petiole without altering its fundamental structure. The newly formed inner vascular bundles consisted of a few xylem elements in the centre surrounded by phloem tissue (Fig 3-B) Both these features are commonly found in many other members of cucurb tace e family (Metcalfe and Chalk 19 7)

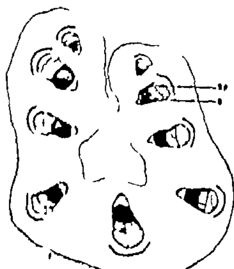
Petioles of cultured leaves became stouter and th cker on root formation. After 14 days of culture of a detached leaf distinct and active cambium at the base of the petiole (Fig 5) was found Cambium produced few secondary xylem elements on th inner side and few second ry phloem cells on the outer side (Fig 6) Inn r cambium of the vascular bundle was not clear However all the vascular bundles did not show the same extent of secondary growth in them. V scular bun lles on the ab xial side of the petiole showed more secondary growth in comparis n to those on the adaxial side (Fig 5) The two v scular bundles of th extreme adaxial side did not show an ary growth (Fig -A)











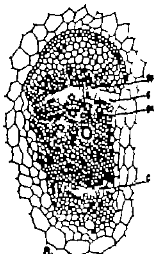


Fig. 3. [illegible] showing splitting of adaxial vascular bundles (A) and [illegible] side (B). X 10.

Fig. 4. A [illegible] from Fig. 3 [illegible] showing [illegible] fascicular cambium (C). X 50.

Fig. 5. [illegible] the base of the [illegible] red for 14 days showing secondary growth [illegible] (B) [illegible] the adaxial side (A) secondary phloem [illegible]

Fig. 6. A [illegible] of Fig. 5 showing [illegible] cambium (C) secondary phloem (Sp) and secondary xylem (Sx). X 50.

Fig. 7. [illegible] of the petiole of a [illegible] red for [illegible] days showing well formed [illegible] phloem (Sp) [illegible] xylem (Sx). X 10.

Fig. 8. A [illegible] Fig. 7 showing secondary phloem (Sp) and secondary xylem (Sx) on the outer side and distinct cambium on both the sides (C). X 50.

The secondary growth was not, however observed when the sections were taken from the middle and the apex of the petiole of the leaf which had been cultured for 14 days. Thus it is clear that the activation of cambial layer and initiation of secondary growth started from the base and progressed upwards

Advanced secondary growth was observed throughout the course of the petioles of the leaves which were cultured for 21 days. Here both outer and inner fascicular cambiums were distinct but only the former was found to be active (Fig 7 and 8) Advancement in the secondary growth within the vascular bundles of the petiole of cultured leaves continued with the incubation days. After 28 days of culture, profuse secondary growth was found to be present in the vascular bundles of the petiole (Figs 9 and 10) A cambium ring at the basal region of the petiole became distinct due to the formation of interfascicular cambium (Figs. 9 and 10) Such a cambium ring however was not present in other regions of the same petiole.

Anatomy of Midrib—The midrib of the lamina of a freshly detached leaf had two vascular bundles lying one above the other Vascular bundle of the upper (adaxial) side was smaller (Fig 11) Like the petiole of a fresh leaf here also the cambium was inconspicuous and no secondary growth was observed even in the midrib of the oldest leaf.

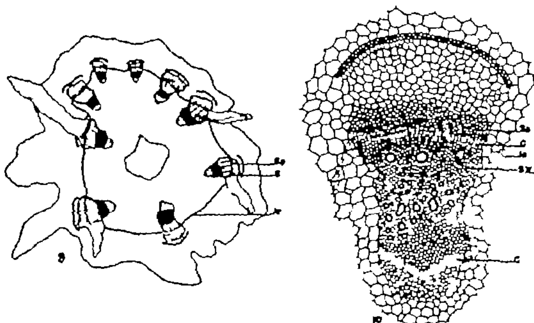


Fig 9 T.S. from the base of the petiole of leaf cultured for 28 days showing interfascicular cambium (I.) secondary phloem (Sp) and secondary xylem (Sx) X 10

Fig 10 A vascular bundle from Fig 9 showing outer and inner fascicular (C) and interfascicular (Ic) cambium and outer secondary phloem (Sp) and secondary xylem (S) X 10.

The section of the midrib taken after 14 days of culturing the leaf did not show any secondary growth though the cambium was dist nct However the cambium was found to be active in the midrib of such leaves which had been cultured for 21 days (Fig 12) The secondary tissues were found to be of the same type as described above for petiole. Increased secondary growth was found in the vascular bundles of the midrib of the leaf which was cultured for 28 days.

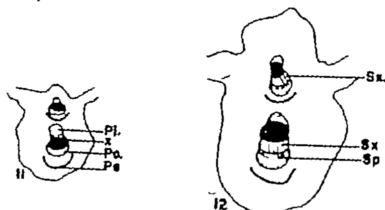


Fig. 11 T.S of the midrib of young leaf (Pl-inner phloem, X-xylem Po-outer phloem, Pe pericycle) X 20.
Fig 12 T.S of the midrib of leaf cultured for 28 days (Sp-secondary phloem, Sx-secondary xylem) X 20

DISCUSSION

The importance of external supply of hormones in the induction of root formation and secondary growth in the detached leaves was emphasized by Mitra and Samantarai (1953) Samantarai and Misra (1953) S mantarai, Misra and Kabi (1953) and Saman arai and Kabi (1954 b) It seems however that the external supply of hormones has perhaps not much function in the formation of roots and secondary growth atleast in some leaves like those of *Urtica dioica* (Gupta, 1957 and 1960) *Boerhaavia diffusa* (Mitra and Nanda Bose 1957) *Luffa aegyptiaca* (Agrawal and Gupta 1964) and *Lagenaria vulgaris*

SUMMARY

Detached leaves of *Lagenaria vulgaris* were cultured in tap and distilled water in orde. to study rooting and anatomical re pons s.

Roots arose from the callus tissue formed at the cut end of the petioles of cultured leaves in 5 10 days. Though roots were formed earlier on tap water their size and number was more on distilled water

No secondary growth was observed in the petiole or midrib of even the oldest leaf of a plant, but secondary growth started in the petiole on culturing a young leaf on tap water for 14 days and in the midrib after 21 days. A complete ring of cambium was observed at the base of the pet ole of a leaf which

had been cultured for 28 days. It was concluded that the activation of fascicular cambium and initiation of secondary growth started from the base of the petiole and progressed upwards

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THE ORIGIN OF LIVING SYSTEMS*

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ABSTRACT

In previous communications [Perti, O N., *Agra Univ J Res* (*Sci.*) XII, Part II 1-48 (1963) Bahadur K. *et al.*, and Perti, O N *et al* *Vigyan Parishad Anusandhan Patrika* 6 94-117 (1963) Bahadur K. *et al.* and Perti O N *et al.*, *Zentralbl f Bakteriology* 117 567-602 (1964)] we had described the preparation of units showing properties of a biological order such as growth replication or multiplication and, in a general sense, metabolic activity These units were termed by us JEEWANU a Sanskrit word meaning particles of life. In the present communication preparation of JEEWANU by many more processes has been described. Evidence of time-lapse photomicrographs has been pre sented in certain cases to show properties of a biological order Confirmation of this work by M. H. Briggs in U.K. in papers recently presented to British Interplanetary Society and at the International Congress on Photobiology has been pointed out. It has been stressed that the available evidence indicates that units such as these were in all probability the immediate precursors of cellular life. These units could easily have been formed in abundance in the oceans of the primitive Earth.

What is lif ? It is not only an interesting question but as Pauling[1] suggests a great question. The very fact that we formulate such a question implies that we are prepared to distinguish between lif and non-life, between living and non-living matter What is that which distinguishes living from the non living ? At first the distinction seems obvious. Animate beings like animal or plants *live* and differ in important ways from the non-living or inanimate objects such as a rock, wood, clay or metal. One distinguishing property of the living is growth up to a limiting size. If growth lone is the distinguishing property then chemical crystals must be called living as they also grow in a suitable en ironment to a limiting size retaining their basic shape and general characteristics. If movement is the distinguishing quality of a living system then metal rods must be called living because they expand and contract with temperature. These simple and rather crude examples have been gi en to show that a rigorous defin tion of life or living system is not an easy task. Moreover the obvious distinctions are patent and isible only on the higher side of the l fe-

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scale. At the lowest side of the life-scale qualities are not so obvious and a clear cut division between the living and the non-living poses a problem of very great magnitude.

It is common experience that living organisms maintain themselves by making use of the material present in the environment in which they live. There is an undoubted fundamental identity of substance between the living and the non-living The structural material of both living and the non-living are known to undergo fundamentally similar physico-chemical behaviour The difference is only in the organisational pattern. This difference has been pointed out in various ways by several scientists who have attempted to define a living system as opposed to a non-living system at the lowest level of life-scale. Haldane[2] calls a living system as a self-perpetuating pattern of chemical reactions" Bernal[3] points that it is an embodiment within a boundary of self-maintaining chemical processes According to Konikova[4] A living thing is a chemical substance or complex which by a process of chemical reactions with the substances of its surroundings, accomplishes its reproduction and development, i.e it remains itself while yet changing (not only in th direction of decay) Life is the attainment, by a chemical substance, of the ability to rebuild itself by interacting with other chemical substances remain ing like itself and beginning to be different from itself. Some like Vernadski have emphasized only the chemical composition of the system particularly with respect to oxygen and carbon while others like Horowitz[6] point out that a living system is not only a self reproducing system but it has also the ability to mutate randoml To Pirie[7] a demand for capacity to mutate is a purely linguistic estriction and it leads to absurdities In fact at the International symposium on 'The Origin of Life on the Earth held at Moscow in 1957 it became quite clear that life is no longer a definable quality As Dr N W Pirie pointed out that all that we can do is to define our attitude towards a system which we would be willing to call as living

No one has yet succeeded in formulating a definition of life or a living system which satisfies every aspect. Only one point seems to be certain that so far as organisation of lif is concerned It is still chemistry and physics as it must be if an organism is to be chemically and physically viable [8] The more we think of the problem on the microscopic scale the more we get con inced that there is a continuity of the non-living and the living and the distinctions begin to have meanings and definitions only at a higher level in the life scale Moreover t is only the dea of a continuity which would make sense when onsider the phenomenon of life on a cosm c scale

Our earth but a minute miniscule of matter in the vast and complex framework of celestial bodies which is the universe. It is merely one of the middling member of the planets going round our sun, the sun in turn is only 1 out of about 150 000 million tars in our galaxy and our galaxy is only one of the millions of galaxies in the universe Shapley estimates that even our galaxy may contain about 100 000 000 planets similar to the earth and capable of sup-

porting life. Sir Harold Spencer Jones[10] Fesenkov and Oparin[11] and others[12] do not think that our solar system is a unique event in the whole of the universe. The general consensus of opinion of astronomers today is that our planetary system is not exceptional. It follows that our earth is not in any way particularly favoured for the existence of the only life in the universe. After all the most fundamental characteristics of the planet earth are a watery environment, moderate temperatures, plenty of minerals and a supply of reasonably stable carbon based molecules. In this biochemical system the present day terrestrial life thrives. Is thus the only kind of biochemical system possible for any type of life? Dr Robert S. Richardson[13] in his book *Man and the Planets* has seriously suggested a possible biochemistry for Mars in which nitrogen may replace oxygen in the energy relations of the organisms. The key reaction suggested is oxidation of nitrogen through ammonia to nitrate. Sir Harold Spencer Jones in his book *Life on other Worlds*[10] has even visualised a special kind of life suitable for high temperature in which the basic life building element is not carbon but sodium. Firsoff in his *Life Beyond the Earth*[14] has pointed out various types of possible biochemical systems to sustain various kinds of life under diverse circumstances of temperature range of atmosphere composition and of different environmental conditions. It is no longer considered unreasonable or absurd to imagine a life different from that found on the present day Earth. Indeed the idea of another kind of life is itself warranted by the study of living forms as known on the Earth.

Up to date known biological facts belie the statement of Strughold that life on the Earth is possible *only generally between the temperature range of 0° to 60° C.* (32° to 140° F). Hot spring bacteria thrive in water having a temperature of 90° C. and some dry spores and seeds can withstand a temperature up to 120° C., without damage. Certain animalculae (rotatoria and tardigrades) living in the Arctic lichens are able to withstand very low temperatures.[16] Penguins are known to live happily at Antarctica at temperatures close to −60° C.[17] Dry spores do not lose their vitality under conditions of vacuum even when dipped in liquid helium (−271.15 C).[18] Thus it is known that life on the Earth can exist from −60 to about +90° C. Even at wider ranges of temperature it can continue in latent form without much damage.

It may also be mentioned here that the general contention of the biologist that no life is possible without oxygen and sunlight is not valid. We know of sulphur bacteria[19] which are capable of existing without oxygen or sunlight and which build up their cell material from inorganic compounds. *Thiobacillus denitrificans* oxidises sulphur at the expense of nitrate and *D. sulphuricans* are known to oxidise hydrogen at the expense of sulphate. The *Boracicola* bacillus is known to thrive in saturated boric acid solution, certain fungi can live in a solution of copper sulphate and potassium nitrate and organisms are also known which can extract sustenance from mercuric chloride.[1, 20] Various bacteria are known to live by oxidising mineral coal and petroleum, methane ammonia ferrous iron sulphur hydrogen sulphide etc. Even

silicate of aluminium is known to be an important constituent in certain type of bacterial metabolism.[30,31] N W Pirie[32] has pointed out activities that we now look upon as odd, e g the manipulation of vanadium oxides and strong sulphuric acid by tunicates, of silica by many species, and of oxides of nitrogen by some beetles, may once have been widespread They often occur in orders of respectable antiquity At the same time we have very cogent reasons to believe that oxygen was a later addition to the primitive atmosphere of the Earth which initially had a reducing character and consisted mostly of hydrogen ammonia and methane.[33] No well known terrestrial life of today could have possibly survived in such an atmosphere except the sulphur bacteria type which could thrive and multiply happily The present oxygen rich atmosphere of the Earth is generally believed to be the result of vegetation

Study of blue green algae led G E. Fogg[34] to conclude that had they been colourless they would be indistinguishable from certain bacteria. This points to a common origin of plants and animals. Similarities in the body fluid of different animals also points in the same direction.[35] Indeed it stands to reason that life adapted itself to the chemical environment that happened to be present from time to time and the modern forms are the forms that gradually evolved, modified complexified and adapted as the environment changed. There was a sort of interaction of primitive life and primitive environment which ultimately resulted in the gradual modification of both. Studies of chemautotrophs provides evidence of the interaction of environment and life.[36]

All this leads us to the inevitable conclusion that different kinds of life are possible under diverse conditions. Given this and keeping in mind the power of adaptability inherent in life, the interaction of life and environment, the biological evolution who knows to what extent any form of life would evolve in appropriate circumstances which need not necessarily be of the Earth-type alone. Though it is a fact that the only kind of life known to us today is terrestrial life yet it is no longer possible to believe that life is a rare accidental event which happened to take place a couple of billion years ago on this isolated speck in the universe—the Earth. That " of all the vast stellar systems Earth is the sole abode of life seems entirely ludicrous" [37] We can no longer adopt the medieval attitude that the Earth is the only measure of life in the universe. Today the climate of human thought in this respect is symbolised by subjects such as astrobiology or exobiology which aim at dealing with experimental approaches to life beyond the Earth and not by the parochial narrowmindedness of the traditional biologist who believes in the creation of life by a series of highly fortuitous events or chances which took place on terrafirma alone. Today Prof James A. Coleman, Chairman of the Department of Physics at American International College Springfield Massachusetts, U.S.A. boldly dedicates his latest book *Modern Theories of the Universe*[38] as follows "This book is ded cated to all youth on all planets in all solar systems throughout the universe."

It is not essential to rigorously define life in order to talk about it. We can discuss the pros and cons of the properties which we must look for in a system to admit it to the category of living systems.

Today it is true that all we know about life is only the modern terrestrial forms of it. It is equally true that we can no longer ignore other possibilities. How can we extend our vision of life ? The process of extension of ideas is a process in which we extrapolate from the known to the unknown. Let us try to follow this process.

To begin with we may say that any kind of life is bound to require a system for its energy supply In all probability this system would be dependent on chemical action which would involve the development of rather complex molecules. A chemical reaction of the type of reversible photochemical reaction can well provide a source of energy within the system. In fact many ordinary reversible chemical reactions can work as a sort of storage battery—absorbing energy at one time and liberating it at another If the environment can provide the necessary cyclic change then a useful source of energy within the system can be obtained.

Let us have a look at the present day terrestrial cell. Th living cell as it is found on the Earth today is a very complicated affair It has within its boundary numerous diverse types of chemicals. It is also known that if we merely bring together all th constituents of the cell we do not get a cell—the living unit. Whereas the known individual constituents of the cell with the exception of nucleic acids have properties of a physico-chemical order the living cell also exhibits properties of a biological order—growth, replication or multiplication and metabolic activity

The modern terrestrial cell has numerous constituents delicately balanced to function in a very synchronised and harmonised manner As a result of this the cell exhibits certain properties of a biological order Is the present day terrestrial cell a unit of life on account of its constituents or on account of its properties of a biological order ? We know that the individual constituents of the cell as a rule do not exhibit properties of a biological order and if th cell did not possess these properties it would cease to be a unit of life. So far as lif phenomenon in general is concerned what is of greater importance—properties of a biological order or the constituents of the cell ? If both the constituents of the present day terrestrial cell and its properties of a biological order are taken to be essential for any kind of life then it follows that we are more or less assuming that no life other than the terrestrial life is ever possible or there cannot be life on any other celestial body which does not very much resemble in all respects the planet Earth. It also implies that we are more or less prepared to accept some one particular cell which sparked off the beginning of life. So we have to make a distinction between constituents of the terrestrial cell and its properties of a biological order If we are inclined to accept and many of us would now be inclined to do so that the phenomenon of life need not be con

fined to life at present known to us on the planet Earth then it follows that we are more or less prepared to accept that the properties of a biological order are of greater importance than the constituents of the cell. It further impl es that we are prepared to accept some carefully generalised meanings of the fundamental properties of a biological order—growth, multiplication and metabolic activity

The more we learn about the constituents of the present day terrestrial cell and its marvellous behaviour the more we wonder about its origin. It appears to be a final finished and polished product which terrestrial Nature arrived at after long and tedious trials rather than a unique chance event in the history of the Earth. It is quite feasible that terrestrial Nature first made a much more complicated product and by gradual refinement and adaptation arrived at the present day cell.[19] It is equally possible that the terrestrial Nature first practiced on primitive type of cells and by gradual complexity arrived at the modern form. One cannot at the same time entirely dismiss the idea of a unique chance event which created the only life in the universe for today we really do not know of any other kind of life except that which is found on this planet.

It would be quite interesting to speculate upon the problem whether the properties of a biological order—growth, multiplication and metabolic activity in the widest sense of these terms—were first created on the Earth in cell-like systems or all the constituents of the present day cell. Many scientists have speculated and experimented on the formation of constituents of the present day terrestrial cell out of the ingredients generally believed to be present n the early age of the planet Earth.[20] Only a few of them have speculated about or experimented upon the properties of a biological order without much refer ence to the constituents of the present day cell. These were the experiments dealing with the preparation of cell models.

In 1864 Traube[21] prepared a cell model by putting copper sulphate crystals in a solution of potassium ferrocyanide. A semipermeable membrane is formed round the crystal. This membrane is permeable to water and ferrocyanide which enters the globule thus formed because of osmotic pressure con siderations and forms another layer beneath the first. The globule swells up because of the excess of water entering the globule and the old membrane bursts and a new one is formed below the cracks. After sometime the globule appears considerably grown in size. However this increase in the size of the globules is quite different from the idea of growth as understood in biology (See also later) Here the increase in size is only because more water enters the globule and there is nothing within the globule other than copper sulphate which is slowly consumed up in the formation of the boundary wall of the globule

Butschl [22] prepared a model of the cell wh ch reproduced the movements of living amebae by rubbing a drop of olive oil with potash solution. The

drop commenced to send out psuedopodia to move about and even to engulf hard particles very much as amebae takes up algae. Rhumbler[22] and many others constructed analogous models reproducing the movements also the fading and division of cells.

Leduc[24,25] placed a piece of fused calcium chloride in a saturated solution of potash and potassium phosphate. Semipermeable calcium phosphate membrane was formed. By changing the concentration of the solution, by adding different substances and by various other means Leduc succeeded in producing very complex formations like algae and mushrooms. This subject was named by him Synthetic Biology"

Kuckuck[26] showed that when radium acts on a mixture of gelatin, glycerol and common salt a peculiar culture appears on the gelatin after 24 hours consisting of the globules showing the signs of growth and multiplication.

This work is important only so far as it shows the display of a few physical properties of matter—properties which appear to superficially simulate some properties of biological order At best such studies merely point out that properties of matter like viscosity surface tension osmosis, permeability colloid formation, coagulation etc. all helped in the formation of the first morphological structure with the properties of the living

Mention may next be made of the efforts to prepare particles of some shap with organic substances with a view to make an effort to introduce in them to properties of a living system. For the past several years work on coacervates[27,28] and microspheres[29,30] is being persued with this aim.

Coacervates are formed by various methods and one of these methods is by mixing gum arabic and gelatin solutions and pouring th mixture in excess of water Coacervate particles of irregular shape are formed. On centrifuging the particles combine and lose their independent existence. Shaking break these particles into smaller ones and this has been suggested as multiplication. Enzymes and other materials if introduced in the coacervate particles are greatly modified It has been suggested by Oparin that life originated in the form of coacervat particle which developed the properties of living system by slow process of molecular evolution and incorporation of enzymes and necessa substrates

In the absence of definit structur without a boundary wall it is diffi lt to assess the living properties of these particles This is particularly so in th case of the phenomenon of growth which is not like the biological type of growth

Mic spheres studied by S. W. Fox and coworkers in United St tes bear a relation hip t pres l model as pres and eported d to Oparin coa cerv tes When hot sat ted sol tions of hermal copolymers containing the 18 common amino acids lk ed t cool huge numbers of uniform, micro-

scopic, relatively firm, and elastic spherules separate which have been termed microspheres. These particles differ in important ways from coacervates. Microspheres retain their integrity on centrifugation[13] whereas coacervate droplets coalesce easily.[13] Microspheres accept the Gram stain[13] and also exhibit some dynamic phenomena.[13] It has been found that under appropriate conditions the interior of the microspheres disappears progressively and entirely leaving behind the outer boundary. At this stage the Brownian motion of the residual centre can also be observed. It has also been observed that in certain microspheres there appears to be a tendency to cleave, or for centres to separate. As cell model the study of microspheres indicates the tendency of macromolecules to form micro spherules by the agency of water formation of membranes in these units by selective diffusion of the interior matter under suitable conditions and a tendency for cleavage of the microspheres. They do not show the biological properties of growth and multiplication.

Studies of such cell models makes us think more about the typical properties of a biological order. Consider the property of adaptability. In biology it means that when there is a mild change in the physico-chemical environment of an organism, changes take place within the organism of such a kind that the unfavourability of the environmental change for the organism is decreased. If this changed condition continues for a sufficiently long time the changed physiology and morphology of the organism becomes a permanent feature. Is this essential property of adaptability a feature of living organism only? In 1888 Le Chatelier gave his famous principle in which he says "If a system in equilibrium is subjected to constraint a change occurs if possible of such a kind that the constraint is partially annulled." Le Chatelier had in mind the chemical equilibrium. It is thus obvious that the tendency to achieve the result of partially annulling the constraint is present in both living and non-living matter. This tendency is called adaptability in living systems because in the living system we can easily conceive the idea of response to stimuli. However it is well known that the response to stimuli is not an essential property of a living system because it is not present in the living system devoid of nerve cells. Further the idea of an effort being made by the living system to face the unfavourable environmental conditions is more or less a figment of our imagination. This is particularly so in the case of the lowest forms of living systems known to exist on the Earth today. The fact is that both in the living and the non-living systems the property of adaptability is inherent and one can say in a gener l way that this is a property of matter whether living or non living.

The property of duplication is another important biological characteristic. Nucleic acids are known to duplicate under appropriate environment. It is worth while to note that it is not the molecule of nucleic acid which forms another molecule of nucleic acid but it is the environment which forms the duplicate out of its own material, the original molecule merely providing the template. This process of duplication of huge protein molecules wh ch we fi d in th p esent ter tral ..

ditions need not be the process of duplication for simpler molecules which might have formed the earliest forms of living systems. *Duplication in essence is really a sort of autocatalysis.* There are many simpler compounds which show autocatalytic action and thus form their own kind in appropriate conditions. We have suggested earlier[46] that matter itself has the inherent property of duplication and under suitable conditions this property can be observed. For example, suppose there is a mixture at dynamic equilibrium. In this mixture there is the possibility of formation of many molecules at the same thermodynamic level and requiring the same amount of energy of activation. Suppose one molecule of one type of the many types of synthesisable molecules is introduced then more molecules of this type shall be synthesised as compared to the other possible syntheses. It is worthwhile pointing that Jordan[47 48 49 50] has shown that if molecule A has a replica of its own a system AA is formed and a special force of stability is created known as quantum mechanical interaction force and the system AA becomes more stable than AB where A and B may be similar but not identical. Pauling[51] pointed out that this special quantum mechanical interaction energy of larger molecules as of proteins is negligible as compared to the interaction energy of identical or non-identical large molecules and suggested that the process of duplication is a two stage process in the case of proteins. A forms a template for the synthesis of complementary molecule A^{-1} *which is then used as the template for the synthesis of A in the* second step. It is quite possible that in the beginning simpler molecules used the one step process of duplication in the living systems and when bigger molecules got incorporated in it then the two step process became necessary

Another characteristic property of the present day terrestrial living systems is metaboli activity Today we find in the terrestrial living system a particular type of metaboli activity which is related to its body material and energy requirements. Consider this metabolic activity at th lowest level of life scale. The essential feature of the metabolic activity is selective assimilation from a suitable environment which ultimately results in the formation of building material or 'body' material of th living unit. It is obvious that in the terrestrial living forms of today there would be one kind of metabolic activity but for another kind of living form an entirely different kind of metabolic activity would be required since the 'body' material would be different. Thus in considering metabolic activity in general on has to keep in mind only two essential features, namely (i) selectively taking up of certain chemicals by the living unit from an ppropriate environment and (ii) ultimate formation of the 'body material' w thin the living unit from this nutrition This concept of metabolic activity is perfectly general a it does not specify th chemicals taken up nor does it specify how the chemicals are transformed into body material' whatever that may be This kind of definition would be suitable for any kind of living system formed out of any material in any ppropriat environment.

Growth is a property which should be very carefully generalised. This growth in the living system should be from inside and not from the outside.

This rules out the type of growth seen in crystals. Consider yeast cells. The growth of yeast cells in different culture media has been studied by Krishna Bahadur and coworkers.[48] They have found that the conditions of the optimum growth is a synonym for a maximum hydration of the protoplasmic material of the cells.[48] This points to the role of hydration in the living systems in general. The living unit must show the living-type of growth. Such a system must have a semipermeable membrane for the boundary through which selective assimilation of suitable chemicals can take place and through which hydration of the system be also possible. In perfectly general terms we may say that the living unit must have a semipermeable boundary through which selective assimilation of suitable chemicals can take place from an appropriate environment resulting ultimately in a growth from *inside*

We would be justified in calling a system living if it has the properties of growth, multiplication and metabolic activity. Growth means the increase in size of the unit from within by actual accumulation of the 'body material' of the unit within a semipermeable boundary. Multiplication means an increase in the number of these units in such a manner that the newer units come into existence through the parent unit. Metabolic activity stands for any series of chemical reactions which take place within the unit as a result of which at least a part of the environmental molecules entering the unit are converted into the body material of the unit. It is *essential* that all these three fundamental biological properties should be present together in the same unit. If only one or two of them are observed then the unit should not be called living. A system or unit can be called living only if it consumes appropriate nutrition becomes bigger by the synthesis of 'body material' from the nutrition consumed and produces its own kind. This definition would hold no matter what ingredients are involved in the making of the units, in the nutrition or in the 'body material'.

We believe that it is possible to prepare such living units in the laboratory both from organic and inorganic constituents or their mixtures.[49, 51] We have been able to prepare such units and have named them JEEWANU which in Sanskrit means 'particles of life'. We also believe that such units were the protocells which ultimately gave rise to present day terrestrial cells. Further given a suitable environment such units are fully capable of forming many types of cells which can ultimately give rise to diverse kind of life.[49, 51, 56]

When freshly prepared these units or globules have a diameter of about 0·2 to 0·5μ. These grow bigger in size during first 6 to 8 days and reach the size of 1 to 1·5μ. Then these give out buds like the buds of the yeast cells. These buds grow in size and become almost equal to the parent unit in a few days. The newly formed bud or the daughter unit may separate from the parent unit or may remain attached to it and bud again and thus start an independent function. As a result after some time clusters of these units having two three or more units attached binary or at angles can be observed. On further aging of the mixture huge clusters of these units are observed in the

mixture to which initially a few units were added. Thus they show the property of growth and multiplication.

The metabolic activity of the above mentioned JEEWANU is proved by the fact that the material constituting these JEEWANU is not present in the environmental medium in the form they are present in the body of the JEEWANU. These Jeewanu have a distinct boundary wall and have a dense centre. The internal structure of these units appears heterogeneous as observed under the microscope du to differences of the refractive index of the material present in them.

The great resemblance of these units to unicellular organisms specially yeast cells is striking. All the experiments dealing w th the preparation of these units were performed under sterilised conditions and great care was taken to work as aseptically as was possible. It was repeatedly found that these units do not represent terrestrial organisms because these do not grow on nutrient agar. Further it was noticed that by changing the chemicals and procedure of their preparation JEEWANU of quit different morphological structure yet having the properties of growth, multiplication and metabolic activity can be obtained. In one case the units do not separate out but remain attached to the parent units and grow branches giving a coral-like appearance. In fact t appears to us that t is possible to prepare the JEEWANU of the desired structure by using different chemicals and controlling physical conditions.

Recently Dr M. H. Briggs[14] has repeated some of our experiments and have even extended them. His conclusion was "Some of these objects possess a morphology similar to that of simple cells. The objects are composed of organic matter very similar to protoplasm. Some also possess weak enzymic activity. There is some evidence that the objects reproduce by budding and are not merely formed continuously from dissolved organi matter.

While the definition of "life and "living" is a difficult problem, it can be said that these microscopic objects satisfy many of the criteria of living cells. It seems entirely probable that objects similar to those observed in the present experiments were formed in bundance in the oceans of the primitive Earth and were the immediat precursors of cellular life.

Dr Briggs observed the fixation of tmospheric nitrogen by these mix tures and its conversion into different amino acids. Among the compounds which he co ld tentatively identify in the microstructures were adenine, guanine, glucose, fructose, anillic acid 3-hydroxy benzoic acid 4-hydroxy phenyl acetic acid and urea. None of these compounds were added i the mixtures used and so they must have been synthesised later on exposure to light. In the precipitates obtained in the mixtures detectable levels of esterase ctivity was found in some, while phosphatase activity was found in others.

The modern cell is not merely a mixture of organic polymers. The organelles of modern cells were not created by a unique chance event. In fact

there is considerable evidence for the evolution of these organelles.[17] Some of this evidence has been indicated by Briggs.[18] All this points to the validity of the suggestion that the first cells or proto-cells were very simple structures devoid of most of the organelles found in the cells of modern organisms. In fact the properties of JEEWANU very emphatically point to the nature of these proto-cells.

The important features of these units termed JEEWANU are —

(i) They are obtained from simple chemicals all of which can be presumed to be available on the primitive Earth.

(ii) The energy source required to initiate the reaction is mild heating, exposure to sunlight or light from a 500 watt—1 000 watt bulb or exposure to ultraviolet radiations of a therapy lamp No extra ordinary physical conditions are required in their production.

(iii) Though they very much resemble yeast cells they actually do not correspond to modern terrestrial organisms as they do not grow on conventional nutrients.

(iv) Once produced by the application of energy mentioned in (ii) they can be seeded in a fresh portion of the original and can then be seen to grow and multiply

(v) They are fairly stable units with a semipermeable boundary wall.

(vi) The composition of these units is not quantitatively the same as of the mixture from which they are produced.

(vii) If suitable organic material is used the units get composed of organic matter very similar to protoplasm.

(viii) Some of these units are found to possess a morphology similar to that of simple cells.

(ix) There is some evidence for enzyme activity of the type of esterase or phosphatase in units prepared out of simple chemicals.

(x) They show biological type of growth, multiplication and metabolic activity

It has been suggested[14] that such units can also be made even with materials containing no amino acids peptides or proteinoids. This has been demon strated by preparing JEEWANU having about 64 14% copper present as cuprous oxide, 4·2 % carbon and 0·28 nitrogen. The rest being hydrogen oxygen, biological minerals and molybdenum. The ash content of these JEEWANU is about 88° and these contain no proteins, peptides or amino acids Yet they show the biological properties of growth, multiplication and metabolic activity In fact their behaviour is practically identical with JEEWANU based on amino acids, peptides etc.

We are of the opinion that on the primitive earth JEEWANU like struc tures were first synthesised from what is known as prebiotic soup[14] from which

life is supposed to originate. To begin with JEEWANU of many types were formed. Perhaps JEEWANU with organic materials originated after the JEEWANU with inorganic material had their day Perhaps both existed simultaneously All these systems had morphological structures and were capable of growth, multiplication and metabolic activity However the JEEWANU which needed inorganic nutrients soon exhausted their supply of nutrition when all the available inorganic nutrients were booked as the body material *whereas the JEEWANU formed from organic material continued their* 'life activity' because their nutrition supply was renewed by photochemical formation. These JEEWANU got a long span of time and evolution produced various forms of the living systems of our Earth.

Bernal has mentioned the possibility of such living systems " There may have been other radically incompatible forms on this Earth at earlier time and these or others we may succeed in making artificially "[29] We believe that JEEWANU are the key to the possibilities of such systems.

We have made the suggestion about the formation of unicellular JEEWANU of inorganic composition. What was their fate ? As suggested earlier perhaps they did not take a long time to book the whole of inorganic nutrition of a particular locality and ceased to live If this was so they would have hardly crossed the unicellular stage and their fossils would be only like the fossils of unicellular organisms. It is quite possible that these unicellular JEEWANU might have formed huge clusters if they grew attached to each other If this was so then it would be worthwhile to search for such type of fossils in various mines from this point of view

Study of JEEWANU formed basically out of organic material strongly suggests a certain sequence in the formation of living systems on the Earth or elsewhere. This sequence may briefly be described as follows.

Life originated in the form of a particle or globule. This particle or globule was bigger than a colloid particl and very much like a coacervate particle. It, however differed from coacervate particle in an important respect This particle was made of such materials that a semipermeabl boundary wall was soon *formed* around it by the coagulation of its material *with the* chemicals of the environment. If appropriat molecules were present in th environment which could form the 'body material' of the particle and if a suitable source of energy necessary for the formation of the 'body material of the particle from the environmental molecules entering the particl was available, the environmental molecules will enter the globule and the body material of the globule will be synthesised because of the inherent properties of duplication and adaptability of matter As a result the particle would become bigger in size from inside This would continue till the limit of flexibility of the boundary wall of the particl ould be reached. At this stage t the weakest point in the membrane a protuberance would be formed very much like the bud type of structure observed in the yeast cells. This phenomenon }

would be a manifestation of the adaptability of matter The constraint caused by the increased pressure inside would be partially annulled when the bud is formed for the pressure inside the particle would decrease. In fact the property of adaptability of matter is not only in operation here but is also present at various stages of the reactions taking place within the particle, in the course of the formation of the material of the particle from the environmental molecules entering it. The mechanism of the formation of these substances is always being adjusted depending upon the physico-chemical conditions within the particle. Pattee[14] has suggested the possibility of formation of protein molecules with specific sequence of amino acids by a computer sort of mechanism and may be the protein molecules or at least the proproteins and enzymically active molecules were formed in the particles described above.

The bud grows in size and may separate from the parent particle or may remain attached to the parent unit and start its independent existence. Thus particles with the properties of growth, multiplication and metabolic activity might have been formed. Such particles have been termed by us JEEWANU and it has been shown that they can be produced and studied in the laboratory by very easy methods. These particles represent the true protocells as it has been noticed that they have the tendency to become more complicated with the passage of time in appropriate environment.

In a subject as vast as the phenomenon of life there is no scope for narrow-mindedness. Even on our planet lif is generally believed to have mad its appearance some 2 3 billion years ago. What might have happened at that remote time under an environmental condition which certainly was not what we have today is anybody's guess. If these guesses are n t to be mere idle speculations we have to use them for the purpose of making certain forecasts or we should be able to use them as the basis of certain experiments. If some observations any how can be obtained which conform in a more or less general way to our speculations then we would be justified in calling our guess a workable provisional hypothesis.

Study of JEEWANU suggests to us a logical sequence in the origin of living systems. Study of different types of JEEWANU strengthens our belief in a universal theory of life—a belief so very dear to workers in the field of what Russians call astrobiology[16] and Americans call exobiology It appears that the phenomenon of life is as much a characteristic of the universe as matter and energy and this phenomenon can take place in different parts of the universe under diverse environmental conditions. Further the distinction between the living and the non-living appears to be a matter for mere convenience for it is possible to so organise non-living matter that it begins to exhibit properties of the living systems as best exemplified by the study of particles called by us JEEW NU Further we can say that the so called non-living matter can exhibit properties of duplication and adaptability under suitabl c rcumstances which suggests that duplication and adaptability are also inher nt pr perties of any kind of matter living or non-living Such an idea is philosoph cally lso

very satisfying. Energy can give rise to matter and matter can be so organised as to give rise to properties of living systems.

Some experimental work on the preparation and properties of certain types of JEEWANU has been described by us earlier[10, 11] In this paper further work on the preparation and properties of different types of JEEWANU has been described

EXPERIMENTAL

In our earlier experiments the general criticism advanced was that there might have been some sort of infection inspite of the precautions taken. We, however pointed out that if these units were the result of some type of infection then they could be grown on the conventional media. Such was not the case. However the production of similar type of units of entirely different composi tion as described here would completely rule out any possible doubt about infection

The glass apparatus such as test tubes, pipettes, conical flasks, measuring glass ware etc. used in the experiments were thoroughly sterilised by heating them in an electric oven for 2 hours at 200 and then sterilising them in an autoclave at 20 lbs. steam pressure for 30 minutes.

The chemicals employed in solutions were A. R. grade The following solutions were used

(i) *Mineral solution* The following composition was dissol ved in 100 ml of glass distilled water

Potassium sulphate	0·02 g
Sodium chloride	0·02 g
Calcium acetate	0·02 g
Magnesium sulphate	0·02 g
Zinc sulphate	0·002g

When a clear solution was obtained then 0·02 g of potassium dihydrogen phosphate was added and the solution shaken to dissol e it. A characteristic of this solution is that it becomes turbid on boil ng and is clear on cool ng Every time this mi eral solution was used it was prepared afresh.

(ii) *Fehling solution* It was prepared in the usual man er

(A) A R. Copper sulphate (69 g) was dissol ved in distilled water (1 litre) containing a little of 2N sulphuric acid.

(B) 100 g sodium hydroxide and 350 g Rochelle salt was dissolved in 1 litre d stilled w ter

Fehling solution used in these experiments was always prepared by mixing equal olumes of (A) and (B)

A (iv) A much larger number of units appeared as compared to A(i) A(ii) or A(iii) but thick elongated conglomerates were rare. Single or double units frequently showed whirling motion of a black spec within the boundary of the unit. Photomicrographs Nos. 6 and 7 show bigger conglomerates with boundary wall

In set B the following mixtures were used.

B(I) same as A(i)
B(ii) -do- A(ii)
B(iii) -do- A(iii)

B (iv) had the following composition —

Fehling solution	2 5 ml
Ammonium molybdate solution	0 7 ml
Gum arabic-sucrose solution	0·7 ml
Artificial sea water	0·6 ml
Formaldehyde solution	0·5 ml

The seeding solution was prepared from B(iv) in the manner described for A(v) 0·01 ml of this seed was added to B(i) B(ii) B(iii) and unboiled B(iv) These mixtures were exposed to light as in case of set A. Some general characteristics of units obtained were as follows —

B (i) Two types of structures were seen. One were transparent globular objects with a black spec inside the boundary These units were motile. The other type were non-motile dark b g structures—single, clusters or conglomerates of units (Photomicrograph No. 8)

B (ii) Structures similar to B( ) Jelly like bigger structures were rare (Nos. 9 10)

Photomicrograph No. 10 shows an interesting composite structure w th boundary wall and internal details.

B (iii) Transparent units were rare otherwise it was all very much like B( )

Photomicrograph No 11 shows smaller units in chains, and No. 12 shows a very big conglomerate.

B (iv) In this thicker clusters were more numerous and transparent structures were rare. Photomicrograph No 13 shows small conglomerates of different shapes and sizes

Set C i) C(ii) C i) and C iv) was similar to set A except that formaldehyde sol tion used in A(i) A ii) A iii) and A(iv) was replaced by an equal volume of arabinose solution. The whole experiment was repeated

C (i) Both transparent and dark type of units were observable. Conglomerates were frequently found They were brown n their outl ne but greenish inside. Photomicrograph No 14 shows both transparent and darker type of units small conglomerates.

C (ii) In this floating jelly-like complex structures in which small globules were embedded could also be seen (No. 15)

C (iii) Single and double units were frequent but bigger aggregates were rare (No 16)

C (iv) All types of units and aggregates seen in C(i) C(ii) and C(iii) could be seen. Photomicrograph No. 17 shows a composite structure.

Set D(i) D(ii) D(iii) and D(iv) was similar to C(i) C(ii) C(iii) and C(iv) except that D(iv) was obtained by replacing mineral solution in C(iv) by an equal volume of artificial sea water The rest of the experiment was repeated.

D (i) Many varieties of structures were found. In some cases con glomerates with circular boundary were seen. These exhibited interesting internal structure (No. 18) Photomicrograph No. 19 shows another type.

D (ii) Both single units having a nucleus and numerous types of aggre gates were visible (Nos. 20 21) Some long striated structures were also seen. Jelly-like transparent globules were also found floating

D (iii) In this solution big conglomerates of units were rare and only single units or smaller aggregates were observable. One bigger unit is shown in photomicrograph No. 22

D (iv) Numerous types of structures could be seen. Filamentous conglomerates were, however rare. By altering depth of focus inner structure of the units or aggregates could be easily seen (No. 23 24)

Set E and F were obtained by modification of sets C and D The sugar arabinose used in solutions of set C and D was replaced by an equal volume of galactose. The rest of the procedure was just a repetition of the process given earlier

E (i) : Single and smaller aggregates of units predominated. Some aggregates were purely green in colour Continuous examina tion through the microscope in one case showed the phenomenon of budding Photomicrograph No. 25 shows an aggregate.

E (ii) : Brown units or their conglomerates could be seen. Most of them had motility The solution also showed a slightly different type of structure which showed whirling motion. Budding similar to the budding of yeast cells could also be observed (No. 26)

E (iii) Single units as well as smaller clusters containing 2, 3 4 or 5 units could be seen. Transparent jelly-like bigger size structures were also found. If the time of exposure to sunlight was increased from 8 hours to 50 hours numerous another type of motile struc tures were also produced as for example see photomicrograph No. 27

E (iv) Bigger conglomerates were rare. An insect like spiral shaped globule could be seen (No 28)

F (i) Some units were thin and transparent and others were thicker and darker They were found single, double or in bunches. Photomicrograph No. 29 shows a peculiar bird like aggregate.

F (ii) Structures like F(i) were seen. Walls of units appeared to be thicker as compared to F(i) Some types of units observed are shown in photomicrograph No. 30

F (iii) Single, double and bigger conglomerates of units could be seen. Some practically colourless units were also observed (No. 31)

F (iv) Practically all types of units given in F(i) F(ii) F(iii) found to be present. Some of them exhibited different stages of growth and budding. One of the conglomerates is shown in photomicrograph No. 32.

Set G and H were obtained by replacing galactose solution in sets E and F respectively by an equal amount of L-ascorbic acid solution. The experiment was then repeated.

G (i) Various types of units and their aggregates could be seen. Colourless transparent motile units such as those frequently observed in set E could not be seen. Photomicrograph No. 33 shows different types of simple units and aggregates. No. 34 shows an interesting cell-like structure.

G (ii) Coloured and colourless units were observed. The boundary wall was brown and the colour inside was green (No. 35)

G (iii) All units and their aggregates found were coloured (No. 36)

G (iv) Practically all types of units as given in G(i) G(ii) and G (iii) could be seen. Photomicrograph No. 37 shows some types.

H (i) : Active units of various sizes could be seen. Conglomerates had as a rule smaller number of units (No. 38)

H (ii) In this solution units formed were as a rule bigger than in any solution of set G Long chains of units were also seen (No. 39)

H (iii) Big conglomerates were not found. In certain cases units single, double or in clusters had a jelly-like transparent envelop (No. 40)

H (iv) Similar to H(iii) but units appeared to have thicker boundary wall (No. 41)

For sets I and J the L-ascorbic acid used in sets G and H was replaced by an equal volume of glucose solution. The experiment was repeated.

I (i) The colour of the units was light green. Single units and clusters were found. Shapes of conglomerates were interesting, for example see photomicrograph No. 42.

I (ii) Same as I(i) Bigger aggregates were less frequently found. Long filamentous structures were also visible (No. 43)

I (iii) Conglomerates were small and less frequent. By altering focus internal structure in some bigger units could be distinctly seen (No. 44)

I (iv) Numerous small size units could be seen. All of them had a black spec inside the boundary which could be seen by altering focus. Jelly-like transparent globules having numerous embedded units were also visible (No. 45)

J (i) In these units a distinct internal structure was easily visible (Nos. 46 47 48)

J (ii) Besides coloured units floating jelly-like bigger globules were also numerous (Nos. 49 50)

J (iii) Objects similar to those in J(i) and J(ii) were observed. Some interesting cases are shown in photomicrograph Nos. 51 52, 53 54 55

J (iv) In this mixture the units were very motile. Aggregates of various shapes and sizes were also visible (Nos. 56 57 58 59)

We had previously described a case of quick preparation of active units with the help of citric acid.[11 14 15] A slightly modified composition given below was employed here.

0·4% citric acid solution	10 ml
Molybdic oxide	0·1 g
Colloidal ferric oxide	10 ml
pH 6·5 phosphat buffer	10 ml
Mineral solution	10 ml
Water	10 ml

Molybdic acid used was prepared by the action of hydrochloric acid on potassium molybdate sol tion till a permanent precipitate appeared The mixture was filtered, the precipitate was washed free from chloride ions and dried. Colloidal ferric oxide was prepared by adding drops of N ferric chloride solution to 500 ml boiling water till tea-coloured solution was obtained.

The abov mixture was exposed to sunlight for 8 hours a day

Photomicrograph No 60 shows these units as they appear in the solution on exposure to sunlight. No. 61 shows the effect after 3 months exposure to sunlight. Further exposure gives rise to numerous long or complicated objects such as shown in photomicrographs Nos. 62 63 64

Experiments were also carried out with tyrosine using a 0·01% aqueous solution. This was exposed to artificial light from a 1000 watt bulb kept at a distance of 1 meter After 3 months exposure an internal structure in the units was developed as illustrated in photomicrograph No. 65. This internal

structure becomes more complicated as the exposure time was further increased. After another 6 months much bigger structures could be seen (No 66) Photomicrograph Nos. 67 68, 69 were taken after 1½ years exposure, and photomicrograph No 70 after 2 years exposure and No 71 after 3 years. If sucrose (0·1 g per 100 ml tyrosine solution) was added in the initial solution then after 2 years of exposure to light structures of the type shown in photomicrograph No. 72 could be seen.

The following composition containing glycine was also exposed to artificial light (1000 watt bulb kept at a distance of 1 meter)

Glycine	0·05 g
Sucrose	0 10 g
Water	100 ml

After 1½ years exposure structures of the type shown in photomicrograph No. 73 could be found.

If glycine in the above solution was replaced by arginine we can get structures of the type shown in No. 74 Replacement of glycine by histidine also gave complicated structures a representative example of which is shown in photomicrograph No. 75

Units based on copper oxide such as those described in sets I and J show many interesting features which are recorded in photomicrographs Nos. 76 to 93

No. 76 shows units immediately after formation.
Nos. 77 78 were taken after five days.
No. 79 was taken after 20 days when germ like structures seem to arise.
No. 80 shows many units having protruding germ like structures.
No. 81 shows that one unit may give out more than one germ like structure.
No 82 the germ of one unit may pass through the other
No. 83 the germs may run in parallel lines.
No. 84 & 85 the germ of one unit may join with the germ of another
No. 86 87 germs may have different arrangements.
No. 88 several germs may arise from the same unit. Notice the characteristic tips of these germs.
No. 89 90 after about one month several units can be observed entangled in transparent germ like structures.
No. 91 92 show coral like growth
No. 93 shows a huge spherical structure which can be sometimes observed.

Sets K and L were obtained by substituting glucose solution in sets I and J by an equal volume of phenyl hydrazine solution The experiments as in sets I and J were repeated.

In sets K and L the units formed initially increase in size and gradually become more complex with increasing time of exposure to sunlight or artificial light. This gradual increase in size and complexity is shown in photomicrographs Nos. 94 95 96 and 97

Here it may be mentioned that recently Kalinenko has announced production of bio-like structures in the laboratory. The first announcement about these structures was given in August 1963 issue of the popular Russian magazine *Science & Life* (Naouka Khizn) and later fuller details were published in Russian journal of Microbiology [41] The abstract of this is :- "Electrical energy causes accumulation in distilled water and in an agar jelly of bio-like structures having the shape of discs, cigars, caudate, rockets, etc.

The bio-like structures formed in the electric field are not of a static pattern. They undergo complete metamorphosis under constant conditions in distilled water or some other medium. The major pattern of this development consists in a delicate morphological differentiation of the body substance and its division into two or more parts.

Electron micrographs point to the conclusion that already at the very moment of its initiation the body of the bio-like structures consists of a solid "nucleus" and a "plasmic" area. Staining with polychrome aniline dyes confirms the heterogeneity of the "nuclear" and "plasmic" matter of these structures. These moieties are stained in different hues phase contrast as well as ultraviolet microscopic observations after staining with fluorochromes (acridine orange) indicate the fine and complex heterogeneity of bio-like structures.

Crystallo-optic observations support our opinion that biolike structures are no crystalline bodies. They do not dissolve in hot or cold water nor are they changed in weak solutions of acetic and hydrochloric acid

Preliminary microchemical analysis carried out so far did not reveal in the composition of the bio-like structures any molecular grouping typical of proteinine organisms."

Experiments of Kalinenko recall the work of Wilhelm Reich which was published in 1948 under the title *Discovery of Orgone* [42] Objects superficially resembling the "bio-like structures can also be obtained from a solution of the type mentioned below

First	Fehling solution	2·5 ml
	Gum-arabic sucrose solution	0·7 ml
	Ammonium molybdat solution	0·7 ml
	Mineral solution	0·6 ml
	Glucose solution	0·5 ml
Second	Fehling solution	1·6 ml
	Ammonium molybdate solution	0·4 ml

Mineral solution	0·7 ml
Sucrose solution	0·8 ml
Glucose solution	0·5 ml
Water	0 8 ml

By exposing such solutions for about 50 hours to sunlight and then allowing them to stand (at 20°) for about a month numerous bio-like structures can be seen in them under the microscope. Some representative examples which apparently superficially compare favourably with bio-like structures described by Kalinenko are given in photomicrographs Nos. 98, 99 100 101 102 and 103

Time-lapse photomicrographs of some JEEWANU For taking time-lapse photomicrographs, the following procedure was employed.

In the combinations given below the mixture was divided into two parts say A and B. Solution A was boiled for 1 minute to give what may be termed the seed solution. It was cooled to room temperature for 30 minutes before use. One or two drops from solution B were placed on a clean microscope slide. A sterilised platinum wire loop was dipped in the "seed" solution (A) and was brought in contact with solution B placed on the microscope slide. It was then covered with a clean big size cover glass. To avoid evaporation sometimes the cover glass was sealed with liquid paraffin. A portion of the slide was kept under view It was also kept exposed to light from a 100 watt microscope lamp. At different times photomicrographs were taken. In each case the mixtures were tested for infection before and after the experiment. They were found to be free from infection.

Combination I	Fehling solution	2 5 ml
	Ammonium molybdate solution	0·7 ml
	Mineral solution	0·6 ml
	Glucose solution	0·5 ml
	Gum arabic sucrose solution	0·7 ml

Two series of photomicrographs obtained from this combination are given

104 a b c and d	These were taken at a difference of 12 hours. They show the formation of a protuberance in a bigger unit.
105 a, b c d, e, f, g	Taken at subsequent differences of 12 hours. These show how complexity in the units is created.

Combination II	Fehling solution	2 5 ml
	Gum arabic solution	0·4 ml
	Mineral solution	0·7 ml
	Sucrose solution	0·8 ml
	Glucose solution	0·5 ml
	Water	0·8 ml

Four series of photomicrographs are given.

106 a, b c They were taken at 0 day 2 days and 6 days. These clearly show how the units grow in size.

107 a, b c, d They were taken at 0 day 1 day ? days and 3 days They show the growth in single and double units.

108 a,b c,d,e,f,g Taken at 0 1 2 3 4 5 and 6 days. They show the phenomenon of growth and increasing complexity

109 a,b,c,d,e,f,g Taken at 0 1 2 3 4 5 and 6 days.

Combination III	Fehling solution	2 5 ml
	Mineral solution	0·7 ml
	Gum arabic solution	0 8 ml
	Glucose solution	0·2 ml
	Water	0·8 ml

110 a, b c and d : They were taken at 0 4 24 and 48 hours They show budding and growth of these units.

Combination IV	Fehling solution	2 5 ml
	Ammonium molybdate solution	1·6 ml
	Mineral solution	0·7 ml
	Gum arabic solution	0·8 ml
	Sucrose solution	0·8 ml
	Glucose solution	1·0 ml
	Water	0·6 ml

111 a, b c and d : Taken at 0 12 23 and 48 minutes.

Note th double units marked with a circle bearing the legend I or II Photomicrographs 111 a and c and 111 b and d are placed in the same order For this the double units have been marked in each of them.

They also show the different views.

Combination V	Fehling solution	2 5 ml
	Potassium molybdate solution	1·6 ml
	Gum arabic solution	0·9 ml
	Mineral solution	0·7 ml
	Sucrose solution	0·8 ml
	Glucose solution	0·5 ml
	Water	0 8 ml

Here in the case of the environmental medium (B) the concentration of gum arabic solution was increased from 0·9 ml to 1·4 ml in the above combination. "Seed" solution (A) was allowed to stand for 3 days before use.

112 a,b,c,d e,f,g,h,i These were taken at 0 1 2 4 5 7 9 12 22 days. Follow the smaller size unit attached to a bigger one. These photomicrographs show the dynamic nature of these units.

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No 60	Mr V Kumar
No 66 67 68 69 73 74	Mr R. S Pande
No. 77 78, 79 112 a b c d e, f, g, h i	Mr A. Kumar
No 111 a, b c d	Mr A. Kumar and Mr V Kumar
No. 80 84 85 and 110 a b, c, d	Dr S Ranganayiki *et al.*,
No 72	Miss I Saxena

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Abstract of Thesis

STUDIES ON *SCOLOPENDRA MORSITANS* LINN *
[PART IV BLOOD VASCULAR SYSTEM & ASSOCIATED STRUCTURES]

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INTRODUCTION

The blood vascular system of the genus *Scolopendra* has been studied by a number of workers *e.g.*, Newport (1843) Duboscq (1697) Herbst (1901) and Bucherl (1939) but their account is rather short and sketchy A summary of the morphology of the blood vascular system n *Scolopendra morsitans* Linn. has been published by the author (1959) The present paper gives in some detail an account of this system including the associated structures.

MATERIAL AND METHODS

The animals were collected and reared in the manner described earlier (Shukla 1963)

Attempts were made to inject the heart with injecting fluid conta ning carmine, by means of hypodermal syringe but no success was achieved. There fore the study of the heart and the various vessels was mad by dissecting the animal under binocular dissecting microscope.

OBSERVATIONS

The blood vascular system consists of a pulsatile dorsal heart, the blood vessels and the blood sinuses.

(A) *The Heart with the Blood Vessels and Sinuses*

The *heart* (Fig 1) is a tubular structure placed along the mid-dorsal line of the body immediately below the terga, extending almost throughout the length of the body from the first to the last segment. Large and well developed alary muscles extend from the heart and are attached to the sides of the body on the tergal plates. These muscles (Fig 2) are typically in fan-shaped groups of fibres spread ng from their point of origin on the tergal plates The heart is contained in the pericardial sinus, situated above and partitioned off from the visceral sinus by a horizontally stretched membrane, the pericardial septum (diaphragm) which has many pe forations through which the pericardial sinus and the visceral si us remain in comm nication with each other The pericardial sinus contains besides the heart, the median

* This is the fourth paper of the series and is part of the thesis approved for the degree of Ph D by the University of Agra in 1957

longitudinal muscles of the body wall masses of fat cells and also masses of special pericardial cells, which are placed on the septum on both sides of the heart The pericardial cells are large and binucleate. Their function is probably excretory but some workers (Hollande, 1922) mention that they may be called as 'Hepatic Cells rather than Renal Cells

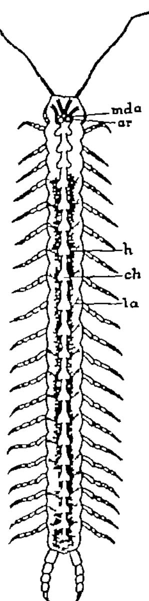


Fig 1

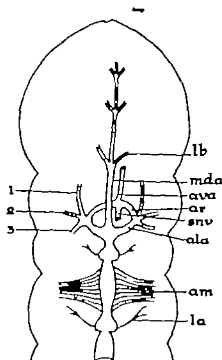


Fig. 2.

Fig. 1 Entire view of heart.
ar aortic ring; ch, chamber h heart; la, lateral artery mda, median dorsal artery

Fig. 2. Anterior part of heart and anterior arteries.
ala, anterior lateral rtery am, alary muscles ar aortic ring; va, anterior ventral aorta; la lateral artery; lb lateral branch; mda, median dorsal aorta sn supraneural vessels 1 2 3, three lateral arteries from the aortic ring

The heart consists of a series of chambers corresponding with the number of segments of the body Each chamber is almost cyl ndrical anteriorly but becomes expanded tow rds the posterior end into two outgrowth l'ke structures one on each side, at the ends of which are situated the ostia which are

provided with valves The chambers are almost of the same size except the first, second and the last which are smalle than the rest.

From each chamber of the heart arise a pair of *lateral arteries* (Fig 2) which after running a short distance divide into two one supplying the fatty tissues and the other the pleural region. From the first chamber which lies at the junction of the first and the second segments, three main arteries are given off one median and two antero-laterals. The median artery is known as the *median dorsal aorta* and runs forward nto the head giving off paired lateral branches and ultimately supplies the brain and other structures in this region of the body The antero-lateral arteries are known as the *circum-oesophageal arteries* and proceed to the ventral side embracing the gut and ultimately meet each other below the latter forming a ring round the oesophagus known as the *aortic ring* From each of the *circum-oesophageal arteries* three arteries are given off the anteriormost supplying the gnathal appendages and the other two the other structures in this region. From the ventral portion of the ring a median vessel is given off anteriorly as well as posteriorly which may be named as the *anterior ventral aorta* and the *supraneural vessel* respectively The *anter or ventral aorta* near the posterior end of the suboesophageal ganglion (Fig 3) divides into two branches which turn ventrally to meet each other below the nerve cord which arises from the posterior end of the suboesophageal ganglion The *supraneural vessel* runs back above the nerve cord right upto the posterior end of the body and gives off a pair of lateral branches in each segment during its course. The heart is innervated by a cardiac nerve which lies on it along its mid-dorsal line.

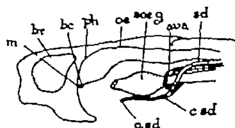


Fig. 3. Sectional diagram of the head.

va, anterior ventral aorta; bc buccal cavity; br brain cad common salivary duct; ph, pharynx; sd, salivary duct; soe.g, suboesophageal ganglion.

The body cavity is a haemocoel and contains the haemocoelic fluid which is also found in the heart aorta and blood vessels. It consists of the plasma and the haemocytes. The plasma is light purple in colour The haemocytes (Fig 4) lie in the plasma and are small rounded cells which may be known as the lymphocytes. Bucherl (1959) in *Scolopendra viridicornis* has described the presence of a very small number of amoeboid haemocytes in addition to the lymphocytes. These amoeboid haemocytes have not been observed by the author in the species *morsitans*

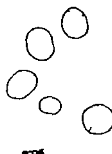


Fig 4 Haemocytes.

(B) *The Course of Circulation*

The heart pulsates in the forward direction by the contraction of the muscles of its wall and the blood is pushed ahead Thus when the systole occurs the blood from the heart is forced forward into the various arteries. The diastole is effected by the contraction of the alary muscles.

(C) *The Fat Body*

The fat body consists of aggregations of fat cells (Fig 5) usually opaquely white and appear like a chain of beads It is irregularly distributed in the pericardial and perivisceral cavities in very large quantity and also in the head and appendages The fat cells are very closely adherent and are densely packed together They contain minute globules of fat and other small granules and the small nucleus lies in the centre. Each cell has got a distinct boundry of its own hence can be easily separated from one another

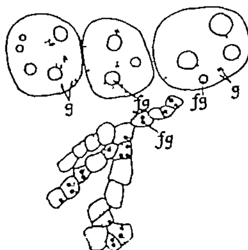


Fig 5. Fat body cells.
fg. fat globules; g granules.

Discussion

As stated in the introduction the blood vascular system of *Scolopendra* has attracted the attention of some workers alongwith other systems. The

account given by them is, however not comprehensive. At the same time, this system has not been described by any previous worker in detail, particularly in the species *morsitans*

The present paper gives a detailed account of the various blood vessels and their branches. In addition to this, some vessels which were unnamed so far have been named. The looping round of the anterior ventral aorta round the ventral nerve cord just posterior to the suboesophageal ganglion has been observed for the first time. Not only this, but the fact that the supra-neural vessel gives off during its course a pair of lateral branches in each segment has also been recorded by the author

The presence of amoeboid haemocytes more or less like those present in insect blood have also been observed by Bucherl (1939) in *Scolopendra viridicornis* but the present author has not been able to find these in *Scolopendra morsitans*

Summary

The heart lies in the pericardial sinus and has as many chambers as the trunk segments. Each chamber is provided with a pair of valvular ostia and gives off a pair of lateral arteries. Three main arteries a median dorsal aorta and a pair of circum-oesophageal arteries are given out from the first chamber The former supply the head region while the latter form a ring round the gut. From the ventral side of the aorti rings runs forward an anterior ventral aorta which forms another ring round the nerve cord immediately behind the sub-oesophageal ganglion The supra-neural blood vessel gives off paired arteries in each segment. The haemocoelic fluid consists of plasma and haemocytes. No amoeboid haemocytes have been observed in *S. morsitans* but binucleate pericardial cells are present. Fat body is found in the body cavity in the form of chain of beads.

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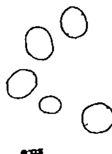


Fig. 4. Haemocytes.

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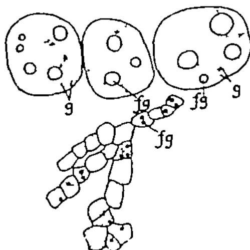


Fig 5 Fat body cells.
fg fat globules; g, granules.

Discussion

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account given by them is, however not comprehensive. At the same time this system has not been described by any previous worker in detail, particularly in the species *morsitans*

The present paper gives a detailed account of the various blood vessels and their branches In addit on to this, some vessels which were unnamed so far have been named. The looping round of the anterior ventral aorta round the ventral nerve cord just posterior to the suboesophageal ganglion has been observed for the first time. Not only this but the fact that the supra-neural vessel gives off during its course, a pair of lateral branches in each segment has also been recorded by the author

The presence of amoeboid haemocytes more or less like those present in insect blood have also been observed by Bucherl (1939) in *Scolopendra viridicornis* but the present author has not been able to find these in *Scolopendra morsitans*

Summary

The heart lies in the pericardial sinus and has as many chambers as the trunk segments. Each chamber is provided with a pair of valvular ostia and gives off a pair of lateral arteries. Three main arteries a median dorsal aorta and a pair of circum-oesophageal arteries are given out from the first chamber The former supply the head region while the latter form a ring round the gut. From the ventral side of the aortic rings runs forward an anterior ventral aorta which forms another ring round the nerve cord immediately behind the sub-oesophageal ganglion The supra-neural blood vessel gives off paired arteries in each segment. The haemocoelic fluid consists of plasma and haemocytes No amoeboid haemocytes have been observed in *S morsitans* but binucleate pericardial cells are present. Fat body is found in the body cavity in the form of chain of beads.

Acknowledgement

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ON EIMERIAN OOCYSTS IN INDIAN GOAT
[An Exogenous Study]*

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Hardcastle (1943) in a check list of *Eimeria* Schneider 1875 included *E. arloingi* (Marotel 1905) Martin 1909 *E parva* Koltan Mocsy and Vajda, 1929 *E. faurei* Moussu and Marotel, 1902) Martin, 1909 *E intricata* Spiegl, 1925 *E longispora* Rudovsky 1922 *E ninakohlyakimovae* Yakimoff and Rastegaieff 1930 as occurring specifically in goat (*Capra hircus*) and *E nana* Yakimoff 1933 in *C sibirica*. Pellérdy (1956) has catalogued *E. arloingi E. crandallis* Honess, 1942 *E. ninakohlyakimovae* in both *C. hircus* and *C sibirica* *E. faurei* in *C sibirica* and *C ibex* *E absata* Honess, 1942 in *C sibirica* and *E. intricata* only in *C hircus* Recently Levine (1961) and Levine *et al* (1962) have listed *E. arloingi* *E crandallis* *E gilruthi* (Chatton 1910) Reichenow and Carini 1937 *E. ninakohlyakimovae* *E. parva* and *E christenseni* Levine *et al* 1962 from goat.

The Indian reports, on the representative eimerian species, are of Bhatia (1938) Ray (H. N 1945 1949) Rao and Hiregaudar (1954) Ray (D K. 1961) and Gill and Katiyar (1961) Thus, *E arloingi* *E. crandallis* *E. faurei* *E. intricata* *E. pallida* Christensen 1938 *E. hawkinsi* Ray 1952 *E. parva* and *E. ninakohlyakimovae* have in all been eported from Indian goat.

In order to estimate the incidence of the eimerian species parasitic in local goats, a survey on six groups including slaughter house material was undertaken during the teaching session, 1961-62. Th oocysts were porulat ed mostly from the rectal contents and their characters of shape, size, colour and sporulation data enabled their specific determination on the criteria proposed by Tyzzer (1929) Yakimoff (1933) and other workers. In all, the six prevalent species were *E. arloingi* *E. crandallis* *E. ninakohlyakimovae* *E parva* *E. faurei* and *E intricata*

E. intricata (Figs 1-4)

This species, originally described by Spiegl from sheep has been report ed in goats by several workers from abroad as well as India.

During the course of the examination of 214 rectal samples of goats, oocysts of this species were found, on two occasions in association with *E arloingi* and once with *E ninakohlyakimovae*. It was not observed in a pure infection

Part of the Thesis approved by the Agra University for the award of M V Sc. degree in 1962.

The oocysts, not only the largest amongst all the coccidia of goat and exhibiting certain characteristic features absent in other species, measured 37 4-51 0 microns in length and 28.9-37 4 microns in breadth with an average size of 45 5 × 32 7 microns. The shape was ellipsoidal to ovoid and shape-index varied from 0 63-0 83 The exocystic wall of the oocysts was very thick and corrugated, of a dark brownish-yellow colour and 2 6 microns in thickness (Fig 1) Being fragile in nature, it could easily break by a slight pressure on the coverslip with a pointed needle. The transparent endocystic wall had a slight yellowish tinge (Fig 2) The large micropyle, 3 4-8.5 microns in size, appeared as a wide gap below the crescent-shaped polar cap which was colourless and 8.5-13 6 microns wide and 2 6-5 4 microns in height (Figs. 1 & 3) The sporont measured in its maximum diameter 20 0 25.8 microns and was not easily visible on account of the darker nature of the oocystic wall (Figs. 1 & 3) The oocysts took 4-6 days to sporulate at the room temperature (Fig 3) The sporocysts (Figs. 3 & 4) pyramidal in shape, had pointed ends. At one of the ends, a colourless stieda body was present. This feature does not appear to have been observed by other workers. The sporocysts measured 17-20 4 × 10.2 11 9 microns in size (length × breadth) A large sporocystic residuum was present.

E. arloingi (Figs. 5 & 6)

This species, the most common of all the coccidian species, was encountered in the 214 rectal samples examined with a percentage of its occurrence at 85 38. Infection purely with *E arloingi*, was observed in 75 cases. It was also present with other species on 31 occasions, the infection was mixed with *E. parva* on 23 with *E crandallis* on 10 with *E ninakohlyakimovae* on 8 with *E. faurei* and on two occasions with *E intricata*.

The capped and typically ellipsoidal oocysts of pale brownish yellow to orange in colour exhibited a great variation in the size measuring 24 65 37 4 microns in length (average 20.3 microns) The prominent crescent shaped polar cap lying above the micropyle, measured 3 4-7 0 × 1 7-3 4 microns in size (Fig 5) The shape-index (breadth/length) ranged from 0 61 -0 82 The sporulation in the laboratory was completed in 24-48 hrs. The oocystic residuum was absent. The ovoid sporocysts, 10 × 5 microns in size, contained a scattered residuum (Fig 6)

E. crandallis (Figs. 7 & 8)

The percentage of its occurrence was found to be 28 51 On one occasion it was seen in a pure infection but generally it occurred with other species 37 times with *E arloingi* 5 times with *E ninakohlyakimovae* 6 times with *E parva* and 5 times with *E faurei*

The oocysts measured 17 23.8 microns in length and 17 22 1 microns in breadth (average size 20 4 × 18 4 microns) The shape index ranged from 0.74-0 93 with an average of 0 83 The oocysts were more or less spherical

to oval or ellipsoidal in shape and of a light yellow colour with a greenish tinge which at times, was very faint or even colourless. The sporont measured 13 6-15.3 microns in maximum diameter. The very small polar cap, at times imperceptible, measured 2 6×0.8 microns (width×height) (Fig 7). The sporulation time, at room temperature, was found to be 24-72 hours. The ovoid sporocysts measured, in average, 13 6×3.6 microns in size (Fig 8)

This species, on account of its double contoured oocystic wall and the character of its polar cap, can easily be differentiated from *E arloingi*. Morgan and Hawkins (1955) have given a key adapted from Christensen (1938) for differentiating the various species of *Eimeria* in sheep. *E crandallis* and *E. parva* have been differentiated from all the other species on the basis of the double contoured cyst wall and separation of these two species has been done as a cap and a micropyle are present in *E crandallis* alone.

Lotze (1953) doubting the validity of this species stated that further studies were necessary to determine its correct status. *E crandallis* appears on morphological grounds alone, to be a valid species. Work on the endogenous stages, in experimental infections which has not so far been undertaken on this species may finally decide this question

E faurei (Figs. 9 & 10)

The original description as cited by Lotze (1953) of *E faurei* is in 1901 Moussu and Marotel described a coccidian parasite of sheep under the name of Coccidium sp., later the same authors (1902) elaborated upon their description and suggested the name *Coccidium faurei*. According to the description of Moussu and Marotel the oocysts were 20-4 microns in length and 18-26 microns in breadth. They were ovoid to sub-spherical in shape and contained a distinct micropyle, 3.5 microns in width. No mention was made of the presence or absence of polar cap. This species has been reported, both in sheep and goats by various authors. From goats it has been described, among others, by Balozet (1932) and Jacob (1943) *and in India by* Ray H N 1949) Rao and Hiregauda (1959) and Ray (D K. 1961)

In the present survey with an *incidence of 10.52*%, it occurred in the various groups, never in pure infections but occurring mixed with *E arloingi* 3 times *E crandallis* 8 times *E ninakohlyakimovae* 5 times and with *E parva* 4 times. The hen egg-shaped oocysts with a brownish yellow colour which, in some had a greenish tinge measured 23.8-34 microns in length (average 29 53 microns) and 18 0-23 0 *microns in* breadth (average 22.36 microns). The prominent micropyle at the narrower end, measured 3 1-5 1 microns in width and had a d... power ... The sporont measured 16.2-20 4 microns in maximum diameter (Fig ...). The sporulation at room temperature was accomplished in 24-48 hours. The ellipsoidal sporocysts with the narrow end measured 1...×8-10 microns in size. The granular sporocystic residual body lay scattered among the sporozoites (Fig. 10)

E. ninakohlyakimovae (Figs. 11 & 12)

According to Christensen (1938) this species, originally described from the oocysts found in goat by Yakimoff and Rastegaieff in 1930 has ovoid or egg-shaped oocysts which are capless and usually without a micropyle, but with a double-contoured wall, measuring 18 9-25 4 microns in length and 14 4-21 microns in breadth. Balozet (1932) had recorded this species both from goats and sheep.

In the present survey the percentage of infection was found to be 23 45 and on 4 occasions the species occurred in pure infection but was associated with *E. parva* 7 times with *E. faurei* 5 times and once occurred mixed with *E. intricata*.

The ovoid to sub-spherical oocysts measured 20 4-26.8 microns in length (average 22.2 microns) and 17 0-20 4 microns in breadth (average 18 08 microns). The shape-index ranged from 0.83-0.91 (average 0 84). The very thin oocystic wall was from light to pale yellowish brown or even dark in colour. The micropyle was imperceptible and the sporont measured 13.6-14 1 microns in maximum diameter (Fig 11). The oocysts took 24-72 hours for sporulation at the prevailing room temperatures. The sporocysts were ovoidal in shape (Fig 12).

E. parva (Figs. 13 to 16)

According to Christensen (1938) Kotlan *et al* described this species from sheep and the oocysts measured 11 4-14 3 microns in length and 9.5-11 8 microns in breadth. It has since been recorded by a number of workers, both in sheep and goat.

During the present study the infection with *E. parva* was encountered in 16.37 of the 214 samples examined. The oocysts in this species are the smallest. It occurred in association with other species thus 20 times with *E. arloingi* 7 times with *E. ninakohlyakimovae* 4 times with *E. faurei* 4 times with *E. crandallis* and 3 times in single infections.

The oocysts measured 13 6-18 7 microns in length and 11 9-15.3 microns in breadth (average 16 2 × 13 4 microns). The shape index ranged from 0 7?-0 95 (average 0 81). The oocysts were ellipsoidal, ovoidal or subspherical in shape. The oocystic wall presenting a distinct double contour on account of the two dark refraction lines measured 0 8 microns in thickness, the colour of the wall varying from a faint yellow to a dark brown or even orange. Micropyle and polar cap were absent. The finely granular sporont measured 10.2 microns (average ... in the maximum diameter (Fig 13). At the prevailing room temperatures, the sporulation required 24-48 hrs. (Figs. 14 & 15). The ellipsoidal sporocyst, with one end rounded and the other pointed and a definite stieda body measured 10 2 × 5 microns in size with a large amount of sporocystic residual body (Fig 16). These sporocystic details

were studied subsequent to the breaking up of the sporulated oocysts from slight pressure attempted with a needle on the cover slip.

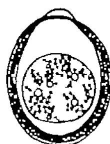
N.B.—Figures 1 to 16 are camera lucida drawings and, with the exception of Fig. No. 16 have been drawn with the same magnification.

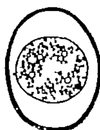
ACKNOWLEDGEMENTS

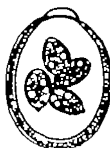
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Fig 1


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16

ON THE COCCIDIAN INFECTIONS OF BUFFALO CALVES*

[A STUDY OF THE OOCYSTS]

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The coccidian species belonging to the genus *Eimeria* Schneider 1875 (Eimeriidae Eimeriinae) recently listed with their synonyms as parasites of cattle by Levine (1961) are *E. alabamensis* Christensen 1941 *E. auburnensis* Christensen and Porter 1939 (syn *E ildefonsoi* Torres and Ramos 1939) *E. bovis* (Zublin, 1908) Fiebiger 1912 [syn *E canadensis* Bruce 1921 (proparte)] *E. thianethi* Gwelessiany 1935 *E brasiliensis* Torres and Ramos 1939 (syn. *E boehmi* Supperer 1952 and *E orlovi* Basanov 19 2) *E bukidnonensis* Tubangui, 1931 (syn *E wyomingensis* Huizinga and Winger 1942 *E khurodensis* Rao and Hiregauda 1934 *E canadensis* Bruce 1921 (syn *E zurnabadensis*) *E cylindrica* Wilson 1931 *E ellipsoidalis* Becker and Frye 1929 *E pellita* Supperer 1952 *E subspherica* Christensen 1941 *E. zurni* (Rivolta, 1878) Martin 1909 [syn *E bovis* (proparte) *E. canadensis* (proparte)] *E bombayensis* Rao and Hiregaudar 1954 and *E. mundaragi* Hiregaudar 1956 The species that appear to have been left out from Levine's list are: *E. azerbaidschanica* Yakimoff 1933 *E aareyi* Rao and Bhatavedekar 1939 *E. gokaki* Rao and Bhatavadekar 1939 and *E. ovoidalis* Ray and Mandal 1961

The coccidia of water buffalo from various countries have so far been reported by Schwartz (1915) and Tubangui (1931) who described infections of carabao with *E. zurni* and *E smithi* Yakimoff (1931) with *E ellipsoidalis* Yakimoff (1933) with *E azerbaidschanica* and Gwelessiany (1935) with *E thianethi*

Sen (1932) recorded from buffalo calves two species known subsequently to be *E. zurni* and *E bovis* The species in cattle that have since been reported are *E. bovis* [=*E smithi* (Rao 1952)] *E zurni* *E. bovis* and *E. cylindrica* by Rao and Hiregauda (19 3) and the two new species *E. bombayensis* and *E. khurodensis* Hiregauda (1956) described another new species *E. mundaragi* Rao and Bhatavadekar (1939) added two more *E aareyi* and *E gokaki* the latter from buffalo calf Gill (19?1) in a preliminary report, recorded from the 2 0 faecal samples examined the incidence of the twelve species *E. zurni* *E bovis* *E. brasiliensis* *E. subspherica* *E cylindrica*, *E bukidnonensis* *E canadensis* *E alabamensis* *E thianethi* *E ellipsoidalis* *E wyomingensis* (=*E ildefonsoi*) and *E auburnensis* and in addition a colour variant of *E cnadensis* Recently Ray and Mandal (1961) added *E ovoidalis* from buffalo calf of West Bengal Thus, out of the twentytwo species reported from bovines (all types) we have seven species specifically reported from buffalo

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* Part of the Thesis approved for the P... degree of Agra University (1962)

Buffalo reared along with cow under the same premises, may mostly share such of the parasites as have a lesser degree of host specificity Eimerian parasites usually recognised as host-specific may not actually be so as identical oocysts, from faecal examinations, are encountered in both cow and buffalo In the absence of requisite details with regard to the endogenous part of life cycle in bovines it would be premature as stressed by Davis (1962) to express considered opinion about the nature of host specificity

With a view to estimate the incidence of various eimerian species, a survey was planned and undertaken mostly in buffaloes of different age groups during the teaching session 1961-62 The faecal samples from 157 calves, ranging from four to five weeks to two years and in adult animals (from local slaughter house) were examined and speciation attempted

MATERIAL AND METHODS

The present study on the exogenous phase, relates to four categories of animals group I of weaned twentyseven male buffalo calves of 4-5 weeks in age (average one month) of which twenty from Agra and seven from Meerut Military Dairy Farms were obtained for instructional purposes in the Department of Gynaecology group II of fifteen buffalo calves of six months age maintained for experimental study on growth rate in Animal Nutrition Department group III of fifty male buffalo calves of two to two and a half years of age and group IV of fortyfour adult animals from the local slaughter house and other sources.

The faecal samples after three washings, were concentrated in 33% sugar solution by centrifugation method for subsequent examination The sugar solution used in group I was of specific gravity 1200 (375 gms. of sugar to 500 cc. of water) with one gm of thymol. Loopful of the material from the top was taken and examined for qualitative analysis of oocysts under coverslip. Sporulation was done in petri dishes of 2½ diameter with 1 2mm. thick 2 5 % potassium dichromate solution placed over the sample with the lids kept half open for aeration In case of the overlapping and all the individual species sporulation was attempted in cavity slides kept over corks in petri dishes containing tap water and examination was done at 8 hourly and 16 hourly intervals. The minimum and maximum temperature of the room, during the period under study was 27 25-31 75 C The relative humidity was not considered as the sporulating material was kept in potassium dichromate solution during the period, July to October 1961 Majority of the oocysts were stained with eosine iodine mixture (Christensen 1938) and drawings made with the camera lucida.

Identification of various species was primarily based on the biometry and morphology of the oocysts and their sporulation time after Yakimoff (1933) Christensen (1938 1941) Morgan and Hawkins (1952) and, Lee and Armour (1959)

OBSERVATIONS

The oocysts encountered and studied, were identified as belonging to : *E. zurni*, *E. bovis*, *E. ellipsoidalis*, *E. cylindrica*, *E. subspherica*, *E. canadensis*, *E. wyomingensis* [a synonym of *E. bukidnonensis* according to Levine (1961)] and *E. thianethi* [a synonym of *E. bovis* according to Levine] and their incidence of occurrence alone or in combinations, observed. In group I the six commonly encountered species were *E. subspherica*, *E. zurnii*, *E. bovis*, *E. ellipsoidalis*, *E. auburnensis* and *E. cylindrica*. In group II the seven species were : *E. bovis*, *E. zurnii*, *E. subspherica*, *E. ellipsoidalis*, *E. canadensis*, *E. cylindrica* and *E. wyomingensis*. In group III all the twelve species were encountered and in group IV the eight species were *E. bovis*, *E. zurnii*, *E. ellipsoidalis*, *E. subspherica*, *E. canadensis*, *E. cylindrica*, *E. auburnensis* and *E. wyomingensis*.

E. bovis with its incidence of 52·23% was followed in order of prevalence by *E. zurnii* (35 8%), *E. ellipsoidalis* (21·02%), *E. subspherica* (21%), *E. auburnensis* (19 17%), *E. cylindrica* (6· 5%) and *E. wyomingensis* (6 67%), the four species, recovered from a few animals being *E. bukidnonensis* (2·59%), *E. brasiliensis* (2%), *E. thianethi* (1.29%) and *E. alabamensis* (1·29%).

From a study of the exogenic features, the bubaline oocysts encountered were found identical to those known from cattle in general.

1. *Eimeria zurnii*

The oocysts are spherical to bluntly ellipsoidal in form with a double-contoured, uniformly thin homogenous and colourless cystic wall with an indistinct micropyle, the rounded and refractile sporont nearly filling up ⅘th of the oocyst. The oocysts agreed with the descriptions given by various authors. The sporulation was completed in 2 3 days and no oocystic residuum was present, each ovoid sporocyst, without a residual body averaged 8 32×5 4 micron in size which is within the known ranges 9·9—11×5 3—5 7 micron (Smith and Graybill) and 7 8—11·2×5·1—5·8 micron (Tubangui) (Figs. 8 & 19).

The oocysts of this species when compared to those of *E. subspherica* have a comparatively thick wall, are bigger in size of a generally round (rarely ellipsoidal) form and with the sporont not so much condensed in proportion to the oocystic size as in *E. ellipsoidalis* which however differs because of the presence of sporocystic residuum.

2. *E. bovis*

The oocyst in this species, the most common in cattle is quite distinct from that of *E. zurnii* because of the presence of a distinct micropyle, Yakimoff and Galouzo (1927) restricted the name *E. zurnii* for the rounded forms and proposed for the oval forms the species, *E. smithi*, now its synonym)

The oval oocysts are brownish, have a thicker and preceptibly double-contoured cyst c wall with the narrower micropylar end exhibiting a dark line being much th nner in its exoocystic region and the rounded sporont of a more granular character and situated towards the broader end Sporulation completed in about 2 3 days leaving no oocystic residuum The ovoid sporocyst with one end tapering and a residual body (composed of granules) of 5 micron in diameter and a distinct sporocystic wall of a light brown colour measured 9·54—14 5×4 9—7 3 micron (average 13 63×6 6 micron) which is within the range given by Yakimoff and Galauzo as 10 8×7·9 micron and 14 4—16·2×7 2—7 5 micron according to Tubangui (Figs. 2 15 23 & 26)

The oocysts in this species though smaller than those of *E aubur*n*ensis* and *E. thianethi* are much bigger than those of *E alabamensis* and also differ markedly from those of *E. canadensis* on account of their shape, *E alabamensis* has no perceptible micropyle and in *E thianethi* the yellowish brown oocysts have radially striated and thicker walls *E aareyi* really comes within the ranges of shape size and form-indices including sporulation time described for *E bovis* The microphotograph given by the joint authors, does not exhibit any marked differences Some of the oocysts studied (Fig 26) on account of their smaller size do show a variation from the minimum range described. Abnormal oocysts with an oocystic res duum have been descr'bed by Yakimoff *et al* (1935) The dark feature of the micropylar end is contiguous with the exocyst and the micropylar gap is 4 5—6 5 micron wide. *E. aareyi* therefore, appears identical to *E bovis* and is accordingly suppressed as its synonym.

3 *Eimeria canadensis*

This species was established for the large ellipsoidal or oval small and round or oval forms of oocysts which now include the previous two species, *E bovis* and *E zurnii* Yakimoff (1931) reported the occurrence, in zebu of *E. zurnabadensis* which was later brought under *E canadensis* by Becker (1934) and Christensen (1941) and *E. canadensis* (Bruce 1921) in parts was also synonymised with *E bovis* and *E zurnii* on account of the measurements given by Bruce, alongwith diagrams—the large and ellipsoidal oocysts having similar characteristics as those of *E zurnabadensis* were thus given a distinct status, on priority basis, to *E canadensis* which has since been treated as a valid species. Lee and Armour (1959) in Nigeria have authenticated it, in complete agreement with the previous workers from biometrical ranges and sporulation data. Gill (1960) found a colourless variant in about 6% of his cases.

The generally ellipsoidal to oval but rarely cylindrical oocysts have, at the narrower end micropyle with a gap of 4-5 micron with a dark streak extending over it. The yellowish brown oocystic wall is about 1 25 micron thick and in some was colourless or li htly tinged. The sporulation was completed n 3-4 da s in the fi e trials undertaken and no oocystic-residuum

was left over The spindle-shaped sporocysts with a distinct wall and tapering ends measure 14·9×7·54 micron in size on average, and contain a sporocystic residuum and refractile globules at each end of the sporozoites

The oocysts of this species, on account of their shape can be differentiated from those of *E. auburnensis* and *E. bovis* in which they are regularly ovoidal. In addition to the form the size is also bigger in the former The oocysts of *E brasiliensis* on losing the cap resemble those in this species but have a much longer sporulation time (Figs 4 & 12)

The oocysts of *E. bombayensis* on account of the range of size, shape and sporulation time come well within those known for *E. canadensis* The joint authors basing their species on the presence of a micropyle of 2-4 micron) in size, differentiated it from *E canadensis* and *F cylindrica* which do not have one end bigger in size, maximum size being 40 micron (average 37 micron in length. Yakimoff had reported the maximum length as 43 2 micron) (average 34 1 micron) Rao and Hiregaudar have mentioned the presence of inconspicuous micropyle in *E. canadensis* *E. bombayensis* therefore, is untenable as a valid species and dropped as a synonym of *E canadensis* The colourless variant, reported by Gill, was not found but we did come across a number of oocysts which were delicately tinged The present record of the species specifically in Indian buffalo would be a first report

4 *Eimeria ellipsoidalis*

This species is considered by many as valid. Yakimoff (1931 1933 & 1935) reported its occurrence in the buffalo (*Bubalus bubalis*) gayal (*Bos frontalis*) and the bison (*Bison bonasus*) Wilson (1931 1933 Becker (1934) Christensen (1941) Hardcastle (1943) Boughton (1945) Davis *et al* (1951) Horton-smith (1958) Lee and Armour (1959) and Marquardt (1960) have all recorded its occurrence in cattle while Prasad (1960) has reported it from black wild-beast. Its occurrence in Indian buffalo appears to be a first report.

The regularly ellipsoidal and colourless oocysts with an imperceptible micropyle exhibited the oocystic wall at the micropylar end thinned out in a few under high power suggesting the presence of a possible micropyle and measured 18 5—28×14 9×18 3 micron (average 21·6×15 35 micron) Christensen had noted it in all the oocysts The spherical sporont was centrally located. Sporulation completed in 3 days and there was no oocystic residuum. The oval to ellipsoidal sporocyst measured 5×3 micron in size which is identical to the one given by Prasad (1960) who however described them as lemon shaped. A sporocystic residuum of rounded shape and composed of many darker granules was present—a feature essentially agreeing with the original authors findings.

These oocysts can be differentiated from those of *E zurnii* in which they are bluntly ellipsoidal and have no sporocystic residuum and from those of

E cylindrica which require a shorter sporulation time, have parallel sides and are of greater length

5 *Eimeria bukidnonensis*

This species with a world wide distribution has a usually low incidence It was encountered in calves of group III and its finding would be the first record from Indian buffalo Comparatively larger oocysts have a thick, striated, yellowish brown wall and are of pyriform shape with a conspicuous micropyle of 3 8 micron wide Our material agrees with the descriptions given by various authors except that the oocysts are considerably smaller than the minimum range indicated (Figs. 11 & 21) The oocysts sporulated in about 6 days leaving no oocystic residuum Sporocysts, 14·4×6 5 micron in size agree with Tubangui's findings of 14·4–21·6×9–11 7 micron (average 19 2×10·1 micron) The elliptical sporocysts with a distinct wall did not show a sporocystic residuum.

On account of the characteristic shape, the oocysts are quite distinct. The smaller sized oocysts, encountered in the present study may probably indicate a separate strain because of the size being smaller than the minimum range given by other workers or it may have been due to the potent host influence (buffalo) Recovery of oocyst in older animals agrees with the observations of other workers.

6 *Eimeria cylindrica*

This species created mainly on the basis of a shorter sporulation period but with no morphological features distinct from such species as *E. ellipsoidalis* has been recognised as a distinct form by Becker (1934) Christensen (1941) Hardcastle (1943) and Boughton (1945) According to Bhatia (1938) it was recorded in India by Taylor Rao and Hiregaudar (1954) have reported it from Aarey Milk colony It has also been reported, in Nigerian cattle by Lee and Armour (1958) Recently Gill (1960) found it in the 12 8% samples among the 250 cattle examined at Izatnagar This species in the present study appeared fairly commonly in buffalo calves

The typically cylindrical oocysts with thin transparent to yellowish-tinged wall and without a visible micropyle have the sporont lying condensed in its middle with the sides somewhat parallel Sporulation completed from 36 to 48 hours and there was no oocystic residuum. The elliptical/elongate sporocysts measuring 9 8×4 microns with a small residual body are single-walled and no steida body was observed. Rao and Hiregaudar (1954) have given the sporocystic size as 6 8×2 1 micron which does not indicate any marked difference (Figs. 6 & 10)

The oocyst can well be differentiated from those of *E. ellipsoidalis* mainly on the size the shape index and the sporulation time. The finding of this species, specifically in buffaloes, appears to be a first record in this animal

7 *Eimeria thianethi* (Synonym *Eimeria khurodensis*)

One of the rare species in bovines it was established from cattle and buffalo during a survey of 125 buffaloes and 1 8 cattle Rao and Hiregaudar (1954) described *E khurodensis* as a new species which really agrees with *E thianethi* from which it was not distinguished by the joint arthors who were also unable to get the sporulation data nor the original author of this species was n possession of these details G ll (1960) reported its occurrence in 2% of the 2.0 samples of cattle examined by him

The oocyst in this species the biggest known from bovines are mostly oval to ellipsoidal in shape yellowish-brown in colour with a very thick wall often seen with two distinct layers—a rough exocyst and a radially striated endocyst contiguous over the micropyle which shows the thinned exocyst, at this spot, giving a characteristic appearance and forming the micropylar cap of 7 54 micron wide. The sporont, 22·2 micron in diameter occupies the larger end and contains many refractile granules. In *E. khurodensis* the sporont is described as of 20-22 micron in diameter

The sporulation was completed in five days and no oocyst residuum was observed The lemon-shaped sporocysts with pointed extremities, appear elliptical in cross section and measured 22·2×9·5 micron in size. Sporocyst residuum was apparent, but stieda body was not observed.

The big-sized oval or ellipsoidal oocyst with thick striated wall make this species distinct from *E. bukidnonensis* in shape and size and from *E wyomingensis* and *E ildefonsoi* in which the walls are smooth and the latter has also a tenue body The figures and description furnished by the joint authors for *E. khurodensis* appear identical with the present material and this species can not be considered valid and is suppressed as a synonym of *E. thianethi*

8. *E brasiliensis*

This species the only one found in cattle with capped oocyst, was originally described from Brazil Hardcastle (1943) Boughton (1945) Davis and Brown (1951) Morgan and Hawkins (1952) have all considered it a a valid species Supperer (1952) established new species, *E boehmi* which was created on the basis of a longer sporulation time. Lee and Armour (1958 & 1959) reporting the occurrence of *E brasiliensis* in Nigerian cattle, found that it was identical, except for the sporulation time, to *E. boehmi* which was reduced as its synonym and the difference in sporulation was believed to have resulted from the temperature differences of the two countries. Hasche and Todd (1959) have also reported its occurrence in Wisconsin (U.S.A.) Marquardt (1959) from a detailed study of the oocysts agreed with Lee's findings

The outstanding character of the oocyst relates to the presence of a polar

cap formed by the endocyst and about 8 micron wide and 2 5 micron high from the wall and is somewhat ell psoidal in shape—the widest diameter being towards the proximal side. The oocyst wall 1 5-2 micron thick, was clear yellowish-tinged the cap being colourless The sporont lay at the distal end. A tenue portion of protoplasm in the micropylar region was observed Sporulation completed in about six days and no oocystic residuum was left over The sporocyst 16 2×6 7 microns in size had the proximal end thickened This size compares with that given by Marquardt (18·2×7·9 micron) \ sporocystic residuum was present

The oocysts that had lost thei caps could be confused with *E canadensis* but can be different ated from them on account of the sporulation time and in the presence of a tenue body—a characteristic of this species (Figs 5 & 25)

Rao and Bhatawadekar (19 9) described their new species *E. gokaki* from buffalo calf mainly on account of the absence in the sporulated oocysts of the tenue body and their smaller size According to Marquardt the extra residual body disappears on sporulation in most oocysts which observation agrees with the present find ng In view of this and the maximum range in size of *E gokaki* ovelapping the minimum range known for *E brasiliensis* and sporulation time being nearly the same *E gokaki* does not stand as a valid species and i dropped as a synonym of *E brasiliensis* Gill (1960) observed infections with tl is species in 14% of the cases (cattle) examined by him. In present study it was en ountered in a ery few cases

9 *Eimeria auburnensis* (Synonym *E mundaragi*)

This species was established from material co lected in Alabama, Maryl nd and Montana Pure culture on feeding alves expe imentally provided uniform ty in size shape colour and sporulation time of the rough and smooth varieties Christensen (1 41) found the smooth variety in greater frequence than the rough one and experimentally also reproduced these. Hardca tle 1943, Bou hton 194) Morg n and Hawk ns (19 2) and Davis and Bowman (19 1) ha e all maintained it as a valid species occurring in Ameri a Lee and Armou (1959) have also reported the occurrence of the smooth va iety in tl e N ia attl and according to Hasel e and Todd (19 9) this was on of the pathoge ic forms. *E mundaragi* Hiregaudar (1956a) appears to resemble l sel *E auburnensis* f which it becomes a synonym

The oval to ellipsoidal oocysts are yellowish brown and smooth-walled (wall being 1—1 1 mi ron th k tapering at the mic opylar end, the micropyle being visit e as a dark l ne Sporul tion took 3-4 days and no oocystic residuum was left over The el n g ted somewhat oval sporocysts, with a distinct wall mea u ed 18 5 4 micr n in size Fig 29) The sporocystic residuum a an elongated clump la between tl e sporozoites. Christensen (1941) ha described it as distributed in haracter

The oocysts, in this species, are much bigger than those in *E. bovis* are more intensely coloured than that of *E. wyomingensis* from which it differs in having a shorter sporulation time and the oocysts being oval in shape. *E. bukidnonensis* and *E. thianethi* have, unlike it, distinctively thick and striated walls.

10 *Eimeria subspherica*

This species occurring in common with *E. zurnii*, was established on account of its smallest oocysts Rao and Bhatawadekar (1960) have reported its occurrence in Bombay and Gill (1960) found it in 9·2% of the 250 cattle examined at Izatnagar No specific record seems to be available of its occurrence in buffalo. It was found in the calves of groups II and III

The subspherical (rarely spherical) oocysts are colourless, with thin transparent walls the sporont filling up almost the interior of the cyst, a perceptible micropyle being absent (Fig 18) On account of their very small size, these oocyst are liable to be missed. Sporulation took about 4 days and no oocystic residuum was left over the spindle-shaped and small sporocysts, measuring 5×3 micron in size contained no sporocystic residuum

The oocysts resemble the spherical form of *E. ellipsoidalis* and the smallest ones in range of *E. zurnii* but are differentiated from these on account of the character of residual body its presence or absence and the differences in the sporulation time.

11 *Eimeria alabamensis*

This species held valid by Hardcastle (1943) Boughton (1945) and Davis and Bowman (1951) was found in 95% of 102 calves by Davis *et al* (1955) who studied its pathogenicity biology and the endogenous phase in 1957 According to them it was rare in calves of 3-9 weeks, but common in those of 3-9 months in age. Hasche and Todd (1959) have reported its occurrence and incidence as a common species found along with *E. auburnensis* *E. ellipsoidalis* and *E. bovis* Lee and Armour (1959) have reported it in Nigerian cattle and Gill in our cattle.

The pyriform oocyst, $13{\cdot}2-15\ 8 \times 11\ 5-12\ 6$ micron ($15{\cdot}2 \times 12\ 8$ micron on average) are without a perceptible micropyl but with a thin, transparent and colourless wall and with the sporont inside being comparatively more granular towards its periphery (Fig 20) A beaded feature, described by Christensen was commonly seen. Sporulation completed in 6 days and no residual body was left over The elongated sporocysts, transparent and thin-walled, were without a sporocystic residuum the shape being quite characteristic without any resemblance to other species.

12 *E. wyomingensis* (Synonym *E. ovoidalis*)

This species, originally discovered in a calf was later encountered in ten other animals. Lee and Armour (1959) have reported its occurrence in

Nigerian cattle and Gill in 8 8% of the 250 cattle examined by him. *E. mundalis* from buffalo calf in West Bengal appears on morphological and sporulation data as indentical to this species. In the present study this species was encountered in the calves of the groups II and III

The ovoid to elongate/ellipsoidal oocysts with 2 5 micron thick smooth walls were yellowish brown in colour the narrower end containing the conspicuous micropyle of 5 5 micron width and measuring 37-40 7×22 2 28 micron in size (average 38 3×23 78 micron) A new variety in colour pattern was also observed. Sporulation completed in 4 to 5 days, an oocystic residuum being absent. The double-walled and pear-shaped sporocysts, with steida body at the acute angle, have in each two refractile globules—the bigger one at the thicker end but the nucleus was indistinct (Fig 24) The sporocysts measured 20 39—22·2 ×7·5—11 11 micron (average 21·22×8·6 micron) the size as described by the original author being 19×3 micron.

The oocysts of this species can be distinguished from those of *E. subrotundis* on account of the shape and size, from those of *E thianethi* in which the wall is thick and striated, from those *E. ildefonsoi* which resembles it in size (31 35—54·15×22 8—34·2 micron average 41 56×27 68 micron) by the presence of a polar granule at the micropylar end. According to Gill, *E ildefonsoi* was synonym of *E ayamangensis* which we do not uphold because, as indicated above these two forms differ markedly A similar view has also been expressed by Lee and Armour (1959) From the available account, *E mundalis* does not seem to exhibit any distinct character except for its pinkish orange colour whereas the oocyst in this species are yellowish-brown but many variants in the colour pattern have been noticed

In most of the species studied even under high power the micropyle not distinctly observed became apparent on staining and in some a depression could be observed The validity of *E azerbaidschanica* Yakimoff 1933 therefore becomes questionable on the character of micropyle being not apparent which otherwise would come within the range of *E ayamangensis* and on the basis of priority the latter should become a synonym of *E azerbaidschanica* which was originally described from buffalo in Transcaucasia Backer (1934) considered it as a distinct species with the remark that it has not yet been reported from cattle which should be watched for Although the description furnished was not complete except for the average size (45×21 6 micron) ratio of length to breadth 2 08 and shape somewhat cylindrical with one surface noticeably less convex than the other which are self contradictory and no micropyle was apparent In 1932 Houizenga and Winger described *E ayamangensis* as a new species giving a detailed description Hardcastle (1943) however stated both species as valid with their hosts —*Bos taurus* and *Buffelus bubali* of *E azerbaidschanica* and only *Bos taurus* of *E ayamangensis* The original authors observed that *E. subrotundis* might be the same as *E ayamangensis* and had only differentiated from *E bukidnonensis*

but described oocyst of *E. myeniageous* as ovoid to elongated ovoidal with a conspicuous micropyle of about 4 7 micron. It is interesting to find that several new species created ha e been retain-d by many workers without having examined the previous accounts.

Discussion

Majority of the eimerian species in cattle are known from the oocystic stages only and as such their differentiation would continue to remain complex as long as our knowledge regarding the differences in their histozoic phases of the lifecycles the location of endogenous stages in the specific regions and data on relative pathogenicity remain obscure. According to Davis (1962) too many 'new species proposed and described in literature, are merely based on size differences and very little of anything else has been considered.

The cr teria for speciation were first promulgated by Tyzzer (1928) who working on poultry included such of the most exact/accurate measures as 'prepatent period' sporulation time host-specificity characteristic habitat, *cross-immunity tests, pathogenicity under both experimental and natural* infestations, morphology of developing tissue phases including shape and size of the oocyst, and relation of the parasite to the host cell together with reac tions of the host. For the morphological differentiation of eimerian oocysts one of the above tests, though easy is incomplete without support from the other criteria. Yakimoff and Galouzo (1927) Becker and Fyre (1929) how ever have differentiated the bovine species on their size, shape and thickness of the oocystic wall, sporocystic size and appearance and presence or absence of sporocystic residual body Tubangui (1931) has applied biometric constants (as shape index, length/breadth, together with probable error obtained through statistical formulae of standard deviations and coefficient of variations) of at least 25-40 oocysts, attaching some importance to the size and shape of the sporocyst and the presence o absence of the residual body Andrews (1931) in a consideration of the validity of the species described in cattle thought that ll species other than *E zurni* were questionable as on generalising on a comparative basis it was found that five days were usually required for *sporulation and they were more in the large intestine than the small one, probably due to the details* available being *insufficient.* Yakimoff *(1933)* however relied on such factors as host-species, size of the oocyst (average) and shape, shape-index (ratio of width over length opposite of Tubangui) colour of the wall micropyle ize of the sporocyst and sporozoite oocystic o sporocystic residual body polar granules, sporulation time and prepatent period, which supplies the informations required as regards morphology of the different oocysts but may not *be of much use in cases of overlapping* ones. Christensen (1937) did n t attach any taxonomic importance to the size of the sporont and sporocysts which were considered reliable by pre vious authors but held that tl e sporulation time and their diagrams alongwith a study of not less than 50 oocysts, from five hosts for avoiding various

strains of the known species preferably of the unsporulated ones, were essential for speciation and in 1941 provided a key for the nine species (including the two new species created by him) for separating them which was later adapted by Morgan and Hawkins (1952) to accommodate the 12 species which they considered as valid. According to Levine (1938, 1942) a differentiation of species on the basis of biometry of the oocysts was not reliable and, therefore, the use of immunological and pathological criteria, similar to those used in *Leishmania* was advocated for recognising the valid species.

To the standard conditions proposed by Christensen, Lee and Armour (1959) added oxygen supply and constant temperature of 27° C for maintaining valid comparisions to their morphological and biological performances. Marquardt (1957) experimenting with *E. zurnii* at 37° C concluded that 50% of the oocysts did not sporulate and their rate of sporulation varied with different grades of temperature. Hence, sporulation time of a species varied under different conditions and there was no need to attach any importance to the standard conditions. However it was felt that this could be of value in cases of intergrading or overlapping species for differentiation, under identical conditions, and to understand their biology at a particular place. Caecal/intestinal samples, if taken for culture, needed a longer time to sporulate than is actually known for the species. The size of the sporont is dependent on the age of the oocyst which in the biggest sporont in its early stages, may almost fill it up but later on gets condensed. This has also been observed by us and is in accordance with the views of Marquardt (1959) for *E. brasiliensis*. Hence no importance can be attached to it.

Size-races or biotypes are commonly found among protozoa. This was noted by Tyzzer (1929) in fowl and has also been taken into account in guinea pig by Lapage (1940) as cited by him. In the present study identification of the species which were similar to those recorded in cattle has mainly been done on —

(i) Biometry and morphology of the oocysts sporulated and unsporulated,

(ii) Sporulation time,

(iii) Presence or absence of sporocystic residuum and,

(iv) The shape-index as biometrical constant which has widely been used since Tubangui (1931) proposed it for eimerian species in bovines but had used length/width whereas a number of workers use width upon length as proposed by Yakimoff (1933). Both the methods are in vogue in the literature. We have utilised width/length for shape index.

The validity of all the species in general and the species overlapping morphologically in particular that have been described can really be decided after the different endogenous phases have fully been known. However

the morphologically distinct species, known to parasitise the alimentary tract of bovines, have been identified and the following key is proposed to separate the thirteen valid species

The species, that have not been considered valid and are suppressed, are:—

E bombayensis Rao and Hiregaudar 1954 *E gokaki* Rao and Bhatewadekar 1959 *E. khurodensis* Rao and Hiregaudar 1954 *E mundaragi* Hiregaudar 1956 and *E. ovoidalis* Ray and Mandal, 1961 The species which Hardcastle, Lee and Armour and Gill considered valid such as *E. wyomingensis* can now be merged with the *E azerbaidschanica* Yakimoff 1933 on priority basis, till such time as the endogenous phases show difference.

Key to the Eimerian Species of Bovines

A. Micropyle imperceptible, relatively small:—

1 Oocyst subspherical to spherical sporocystic residuum abse[illegible]
Oocyst ellipsoidal to cylindrical sporocystic residuum prese[illegible]

2 Oocyst subspherical, sporulation time longer than [illegible]
11 × 10·4 micron [illegible]
Oocyst ovoidal size 18 9 × 13·4 micron [illegible]
sporulation time longer than 96-120 hours [illegible]
Oocyst spherical larger size 18 × 16·4 micron, [illegible]
hours [illegible]

3 Oocyst more ellipsoidal, size 21·6 × 15·35 [illegible]
48-72 hours [illegible]
Oocyst larger more cylindrical, with [illegible]
25 × 15 micron sporulation time [illegible]

B. Micropyle perceptible relatively large [illegible]

4 Oocyst with a polar body [illegible]
Oocyst without a polar body

5 Cap present size 40 × 29 micr[illegible]
Cap absent, size 41·8 × 27·6 [illegible]

6. Oocystic wall thicker [illegible]
Oocystic wall thicker [illegible]

7 Oocyst more pyriform, [illegible]
sporulation time 144 [illegible]
Oocyst more ellipsoi[illegible]
tion time 120-144 hours [illegible]

8 Oocyst oval shorter [illegible]
hours [illegible]

Oocyst oval to pyriform, large, smooth (some-times rough) size 35×24 micron sporulation time 48-72 hours. *E. auburnensis*
Oocyst oval to ellipsoidal size 27×22 micron sporulation time 72-96 hours. *E. canadensis*
Oocyst oval to ellipsoidal size 38×24.5 micron, sporulation time 120-168 hours *E. wyomingensis*
(The dimensions given are the average size of the oocysts)

Summary

Coccidian infection in local *Bubalus bubalis* showed an incidence of the twelve different species *E. bovis* 39·25%, *E. zurnii* 35.8%, *E. ellipsoidalis* 21·02%, *E. subspherica* 21%, *E. auburnensis* 19·1%, *E. canadensis* 17.2%, *E. wyomingensis* 6.67%, *E. cylindrica* 6.67%, *E. bukidnonensis* 2.59%, *E. brasiliensis* 2%, *E. thianethi* 1.29% and *E. alabamensis* 1·29% of the total of 157 cases examined. Their identification mostly from the exogenous phases, has been indicated in matter of incidence of the various species occurring singly or in combination in groups of animals including one month old calves. The data has been presented, after outlining the previous work on bovine coccidian parasites, from abroad and India.

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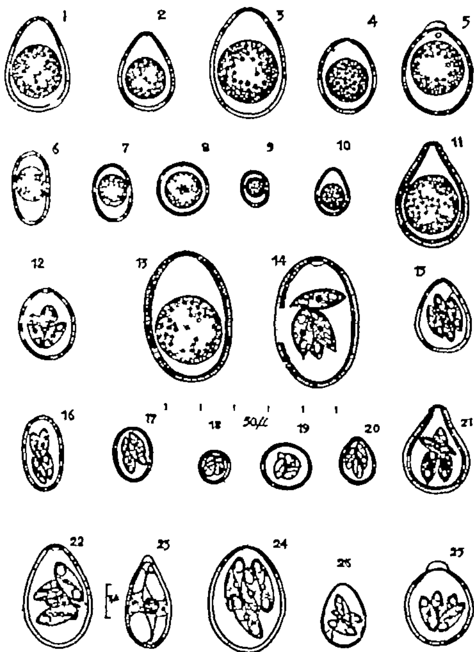
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Explanation of Figures

Unsporulated oocysts—Fig. 1 *E. auburnensis* Fig. 2 *E. bovis*
Fig. 3 *E. wyomingensis* Fig. 4 *E. canadensis*
Fig. 5 *E. brasiliensis* Fig. 6 *E. cylindrica*
Fig. 7 *E. ellipsoidalis* Fig. 8 *E. zurnii*
Fig. 9 *E. subspherica* Fig. 10 *E. alabamensis*
Fig. 11 *E. bukidnonensis* Fig. 13 *E. thianethi*

Sporulated oocysts— Fig. 12 *E. canadensis* Fig. 14 *E. thianethi*
Fig. 15, Fig. 26 *E. bovis* Fig. 16 *E. cylindrica*
Fig. 17 *E. ellipsoidalis* Fig. 18 *E. subspherica*
Fig. 19 *E. zurnii* Fig. 20 *E. alabamensis*
Fig. 21 *E. bukidnonensis* Fig. 22 *E. auburnensis*
Fig. 23 *E. bovis* (sporocyst) Fig. 24 *E. wyomingensis*
Fig. 25 *E. brasiliensis*


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ON HELMINTHIC NODULES IN THE SMALL INTESTINE OF BUFFALO AND COW CALVES*

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U P College of Vet. Sc & A. H Mathura.

Different categories of prominently developed helminthic nodules, associated with paracooperial, oesophagostomal and strongyloidal infections, were encountered in the small intestines of buffalo calves autopsied. In addition to the differences in the morphological characters of the harboured stages these nodules also differed in their location and the overall pathological picture. The material, studied histologically and briefly described below relates to a few features observed in regard to *Paracooperia nodulosa* (Schwartz 1928) Travassos, 1937 *Oesophagostomum radiatum* (Rud. 1803) and *Strongyloides papillosus* (Wedl. 1856) Ransom, 1911 which has been dealt with elsewhere.

During post-mortem examination of a cow calf (less than three months of age) two types of prominent nodules were observed on the inner lining of the small intestine one of these was oesophagostomal while the other which was small and somewhat differently located, was more towards the mucosal surface. The latter after histological study proved to be due to a cooperid infection. The paracooperial nodules, in buffalo calves, involving large areas especially, of the small intestine and their developmental stages have been studied by other workers as well and p evious work reviewed by Sharma *et* Pande (1963)

Paracooperial

The collections, made from buffalo calves in the age group of three to six months and above, yielded numerous nodules from which the juvenile forms, in fourth and fifth stages, were collected after teasing. Histological studies of these nodulated areas, from series of sections, did not aff rd any fresh data. In one case, however *the serial sections of one of the distinctly smaller nodules* presented a p cture entirely different not only in regard to its location but in the nature of the pathological changes around the harboured stage which unlike the condition known so far consisted of both male and female pre-adult forms (in their early fifth stage)—the former with fully formed spicules and bursal rays and the latter with its full complement of external genitalia (Fig 1) The localisation involving the muscle bundles did not affect in any way the mucosal part

On histological examination, the contained stages occurred between the muscle bundles with an indistinctly thin fibrous encapsulation. From degene-

*Part of the Thesis submitted for M. V Sc. degree of Agra University (1963).

ration of the muscles a clear space harbouring the parasite had resulted and an allround fibroblastic activity was in evidence. The adjoining muscles were also degenerated and the fibroblastic elements showed an infiltration with lymphocytes and macrophages The mucosa and sub-mucosa did not appear to have been affected except for the presence of a few lymphocytes (Fig. 2)

In case of the nodules normally developing in *P nodulosa* infection a single preadult (early fifth stage) invariably occurs in one nodule and the well developed fibrus encapsulation involves the mucosal sub-mucosal and muscular layers. The encapsulated area exhibits a fibroblastic activity and a heavy infiltration with lymphocytes macrophages and eosinophils, the latter occurring in greater concentration in patches towards the degenerated sub-mucosal surface A complete degeneration of underlying muscle bundles inside the nodule leads to fibrosis and infiltration with identical cells This histopathological condition encountered normally was entirely different from the present material which involved the muscular region alone. The presence of both male and female forms occuring together and the extremely different picture of the changes observed in an hitherto unrecorded location is only explainable in consequence of these forms having secondarily invaded this area.

Oesophagostomal

The oesophagostomal nodules studied both in the buffalo calves and cow calf have the large intestine as their usual site and were of similar sizes. Histological study of nodules occurring in the region of the small intestine, revealed a histopathological picture identical to that formed in affections of the la ge intestine The harboured stages on account of the character of anterior region and their oesophageal glands were easily identifiable. These were all fourth stage juveniles (Fig 3) (a tooth inside buccal capsule was present n both types of hosts) Besides, the characteristic pathological picture largely in olved the sub-mucosal region the muscular bundle being least affected The reactions in both the bubaline and bovine material consi sted of encapsulation in the sub-mucosa with a cheesy mass occupying the major part of the nodule and surrounded by fibroblastic activity with an infiltration of leucoytes, l mphocytes, macrophages and a few eosinophils (Fig 4) Mucosa revealed a partial degeneration and an infiltration with identical cells. The underlying muscular layer wa apparently less affected The oesophagostomal nodules in calves in heavy infestations exte d to the regions of the small intestine as well

Cooperial

The smaller-sized nodules, identified herein as cooperid, were found in the cow calf and involved both the mucosal and sub-mucosal coats. The harbour ed stage was identified from the structure of its anterior end and was confirm ed from the presence of a few adults of *Cooperia laterouniformis* Chen 1937 recovered from the lumen Unlike the paracooperial nodule, the period of

residence of its harboured stage would distinctly have been much less as there was no indication of any differentiation in the external genitalia. The nodule had slightly raised the sub-mucosa as a result of a thin encapsulation (Fig. 5). The reactions involved however appeared less significant than those in oesophagostomal nodule because of a lesser degree of necrosis in the centre. The harboured stage exhibited, around it, a fibroblastic activity infiltrated with leucocytes, lymphocytes and eosinophils (Fig. 6). The mucosa also showed similar changes but the muscle bundles were however normal.

Working on the life history of *Cooperia curticei* Andrew (1939) stated that these nodules were formed around the nematodes in the intestinal mucosa. According to Newsom (1952) Andrew considered that the nodules, formed around the immature parasites in the intestinal crypts, were later necrosed and calcified which was believed to have resulted from immunity developed to the parasite. The present finding of cooperial nodules, in a cow calf is in conformity with Andrew's record. Bhatia (1961) in his observation on *C. punctata* infection in hill sheep described from sections of prominent nodules a centrally necrosed area surrounded by fibroblasts and leucocytic infiltration but did not find a stage of the parasite. Andrew's record and Bhatia's report show that in cooperial infection the third stage larva may enter the mucosal lining and reside for sometime. Subsequent work may give additional information.

Summary

The three distinct types of nodules observed in the wall of the small intestine in the buffalo including the ones in the cow calf were from *P. nodulosa*, *O. radiatum* and *S. papillosus*. These have been differentiated after histological study. Paracooperial infection in the present study was found to show a secondary invasion of an adjacent area by both male and female preadult stages, the nature and extent of damage observed being distinctly different from the pathological picture encountered in the normal paracooperial nodules. Besides a cow calf revealed in its small intestine, in addition to oesophagostomal nodules, generally described from large intestine, a smaller sized nodule which has been identified as due to a cooperid species, *C. tolerowi* formis of which a few adult forms were also collected.

Acknowledgement

The author is highly indebted to Dr. B. P. Pande, M.Sc., D.Sc., Professor and Head of the Department of Parasitology for his kind guidance. Thanks are also due to the Principal of the College for facilities provided.

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Fig 1 Camera lucida drawi g of section of small intestine showing paracooperid male and femal (pre-adult) in bet een the muscl bundles with degeneration and cellular reaction



Fig 2 Photomicrograph of portion of (Fig. 1) showing reaction round the pre-adult worm lying in between muscle bundles, consisting of degeneration fibrosis and monocellular infiltration. X 170



Fig. 3 Photomicrograph of portion of section of oesophagostomal nodule in the small intestine of buffalo calf showing anterior end of larva exhibiting buccal capsule and tooth. (observe associated pathological changes) X 80

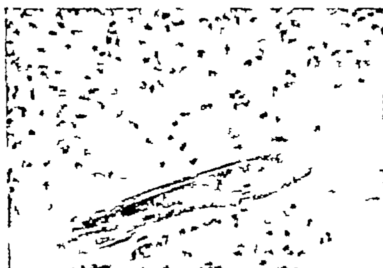


Fig. 6 Photomicrograph of portion of section of ooperid nod l in small intestine of cow calf. (not th longitudinally worm and reactionary cell infiltrated around it) X 90



Fig 4 Photomicrograph of ... p ... of ... [illegible] ... all inter... [illegible] ... X 3...



Fig 5 C... [illegible] end of C... [illegible] fied anterior ... [illegible]

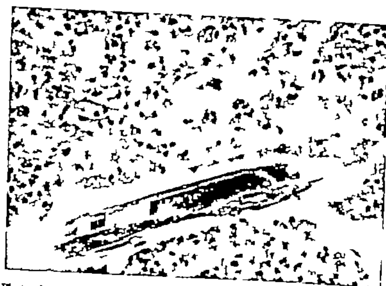


Fig. 6 Photomicrograph of portion of section of cooperid nodul in small intestine of cow calf. (note the longitudinally cut worm and reactionary cells infiltrated around it.) X 90

STUDIES ON THE EFFECT OF SURFACTANTS ON COLLOIDS APPLICATION TO SUGAR INDUSTRY

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Manufacture of sugar is the second largest industry in India and the development of various processes involved therein for the production of better quality sugar is the subject of many research projects. In India, sugar is manufactured from cane juice that contains app eciable quantities of colloids which are necessarily to be eliminated before sugar is obtained in the crystalline state. The removal of the colloids and other interfering non-sugar constituents forms the principal object of the two clarification processes *viz.* sulphitation and carbonation processes which are in vogue in the country The elimination of colloids in these two processes is not complete and merits investigation Review of the literature shows the remarkable property of the surface active agents in altering the surface properties of the substances and coagulating the colloids Studies on the use of the surfactants for achieving better clarification of cane juice form the pr n-cipal object of dissertation

The thesis consisted in all six chapters including the first introductory chapter

Detailed investigations were made on the determination of the relative precipitation values of various commercially available surfactants (Chapter 2) These results are of marked importance for the use of surfactants in any technical process. Of the various commerical surfactants cetyl pyridinium bromide (CPB-Fixanol C) appeared to be very effective. The nfluence of surfactants on the coagulation of colloids, nvestigated in detail, was discussed. Cationl surfactants precipitated only the negatively charged colloids, while the anionic ones affected the colloids with positive charge. Turbidiometric investigations showed that the effect of concentration (C_s) of surfactants on the colloids was principally two fold (i) at low values C coagulation occured (ii) at large v lues of C the coagulum redispersed with a reversal f harge on the colloidal particles The essential difference between the influence of surfactants and inorganic electrolytes on colloids was that in general, (ii) was not observed with the latter The stability factor (W) of the system was determined in the two regions. Under all circumstances W varied with C_s and obeyed the following equation, which follow from Overbeek's theory of coagulation of colloids:

$$\log W = K_1 \log C + K_2$$

where K and K_2 were constants While in (i) W decreased with C_s indicating the process of oagulation, in (ii) W increased with C_s suggesting the

Abstract of the thesis submitted to the Agra University for the degre of Doctor Philosophy

the system was acquiring stability indicating dispersion by the addition of increasing quantities of surfactants. These data clearly demonstrated the necessity of the use of limited quantities of surfactants for complete precipitation of colloids. Thus concentration (S) of the surfactant required for com lete coagulation varied linearly with concentration (C) of the colloid present in the system The following relationship was found to be applicable

$$S = mC$$

where m was a constant dependent upon the nature of the surfactant, temperature, etc. The linear plot of S and C passing through origin suggested the development of a new method for estimation of colloids in technical sugar solutions for which no simple and accurate method was available. The new method employing surfactants was described in detail in Chapter 3

As pointed out earlier the colloids present in cane juice are eliminated inpart in sulphitation clarification process appreciable amount of colloidal matter contributing to the colour of the system remained still in sulphitation juice The data on the use of surfactants such as CPB on the removal of this colloidal matter was reported in Chapter 4 When 0 225 per cent of CPB was added to the sulphited cane juice and boiled clear juice with little colloidal material was obtained Apart from the precipitation of the colloidal m terial addition of surfa tants did not affe t favourably the other ch r cterst c of the jui e such as settling propert etc. This modification resulting in the improveme t of the sulphitation process did not involve any radical change i the existing process and was patented.

In chapter 5 was reported data on the development of a new clarification p ocess of cane juice employi g urf ctants Cane juice contained 0 02 to 0.3 per cent of olloids which were mainly negatively charged in nature. When 0 1 per cent of catio ic su factant was added to the cane juice at pH 7.0 and boiled clear juice with re narkable clar ty comparable to that obtained usually n carbonation process was obtained on filtration. Th s not only simplified the clarifi ati n te hnique l ut also eliminated the entirety of colloids. The new process which was examined o a pilot plant scale in the E peri mental Sug r Factory attached to the National Sugar Institute (Kanpur) and wh ch was patented w is as follows

i heat the mi ed juice to 6 ·°C

(ii lim to rise the pH f om .3 to 0

(iii) Add Fi an C" (0 1 per cent on cane juice)

(iv) heat to boiling

v) filter to obtain clarified juice

(vi) evaporate in qu druple effect ev por tors

(vii) end syrup to the pan thout sulphit t on The advantages and the disadv intages f the process o er the con ventional cla ification techniques were discussed

Cationic surfactants affect only the colloids with negative charge while anionic ones coagulate the positivel charged colloids (vide supra) The investigations made on the nature of colloids present in thus d fferent clarified juices employing this characteristic features of surfactants were reported in the last Chapter Addition of cationic surfactants to sulphitation juice gave appreciable coagulum while no coagulation was noticed therein with anionic surfactants indicating the presence of negatively charged colloid particles only in sulphitation juice Remarkably enough cationic surfactants did not however produce any coagulation while anionic surfactants gave coagulum in carbonation juice this observation suggests fo the first time in this field of research that carbonation juice contained positively charged colloidal particles. Essentially similar data were obtained by employing cataphoretic technique using Tiselius electrophoresis apparatus. W th th s it was o served that particles of sulphitation juice moved towards the anode while those in carbonation juice migrated towards the cathode That is the raw cane juice containing colloids with a negative charge when clarified by the two processes gives systems, containing different types of colloids. Though th s obser ation seem at present to be of no practical or technical importance it is however of marked theoretical significance.

At tl end of the Thesis were appended the reprints of the following papers publihsed b the author on the subject matter presented in this dissertation

(I) N A. Ramaiah, R Dayal Srivastava and K K. Rao Proceed ngs of S T A (India) 1960 (Part II p. 196

(I) N A Ramaiah and R Dayal Srivastava ibid 1961 (Part II) p 119

(II) N A. Ramai h and R. Dayal Srivastava ibid 1962 (Part I) p 85.

(iv) R Dayal Srivastava and K A Prabhu, ibid 1962 (Part I) p. 93

PHYSIOLOGICAL-ECOLOGICAL STUDIES OF SAL (SHOREA ROBUSTA GAERTN) FORESTS OF UTTAR PRADESH WITH SPECIAL REFERENCE TO REGENERATION*

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Introduction

T oup (1921) in the introduction of his monumental work stated that "there is no branch of Indian forestry more important than the study of natural reproduction" This is particularly applicable in the case of *Shorea robusta* forests which are not regenerating well in several large tracts in Uttar Pradesh As is well known, *Shorea robusta* is one of the most important timber tree species of India. The management of these revenue yielding forests is being hampered by the lack of natural regeneration in most of the valuable high quality sal areas specially in submontane and *tarai* divisions, namely Haldwani, Ramnagar and Bahraich where the standing crops of good quality sal do not have adequate advance growth It has been noticed that the paucity of regeneration is attributable to the following factors (') lack of sufficient recruitment in the shape of new seedlings (i) failure of seedlings to survive and grow up. Whatever seedlings survive the first year gradually succumb to unknown causes, (iii) the habit of dying back which esults in seedl ngs surviving for a large number of years in stagnant condition in the form of whippy plants which produce thin switchy shoots annually that may die back every yea and which in any case fail to develop into woody plants capable of growing up normally The failure of seedlings to establish in a reasonable time is eceiving th attention of forest officers and other scientists since about last 50 years but despite many advances a pract cable technique has so far not been evolved for regenerating these forests successfully

Review f the past work

In the past, a few workers have studied some of the basic ecological and ph ological aspects of this problem. Probably Hole s (1914) work was one of the first systematic studies in this direction. After conducting a set of experi ments extended over a period of three years he concluded that the dying-back so ommonly observed is not an inherent characteristic of sal but is caused by bad soil aerat on and drought. The accumulation of dead leaves according to him has a deleterious ffect on seed germination and recruitment firstly because t prevent seeds from coming in contact with the soil moisture and secondly bec use t obst ucts the passage of the radicle into the soil. He ecommended emov l f overhead canopy in patches (i) removal of dead lea es by

Summary of the thesis submitted to the Agra University for the degree of Doctor of Philosophy

burning and (iii) hoeing for soil aeration in moist forests while (i) introduction of underwood as soil protection and (ii) preventing run off of rain water and encouraging of percolation into the soil by cultivation and trenching in dry type sal. Troup (1921) on the basis of Hole's work and his own experience gave some similar suggestions fo obtaining satisfacotry regeneration of sal. Champion (1933) while writing his monograph on sal on the basis of available data and his own wide experience, stressed the need for detailed knowledge about successional trends of the various sal forests, so that proper silvicultural operations may be adopted for obtaining natural regeneration. After explaining the possible trends of succession in different types of sal forests in brief he suggested proper silvicultural and management practices that would favour progression in dry types while checking it in the moist types, which could help in the establishment of seedlings.

Other workers such as Smythies (1936) Warren (1940) and Raynor (1940) also suggested some definite techniques for obtaining regeneration in different types of sal forests. Attempts were also made (Sen and Ghose 1929 Griffith and Gupta 1947) to study the soil characteristics in order to determine the cause of dying back of sal seedlings. Hewetson (1955) while discussing the ecological status of sal in Central India indicated some important lines on which future research should be attempted. Puri (1953) studied the pH of surface soils in some communities of B_3 type sal of Dun valley and concluded that the problem of sal regeneration in U P is probably the result of the decrease in acidity of the soils resulting from evaporation from the surface of exposed soils in felled areas or from human influence and fire Seth (1951 55) gave an excellent review of the present position of sal regeneration and various silvicultural techniques being adopted in different types of forests and suggested further lines of research to solve the problem.

As a contribution towards intensive study of locality factors and basic relationships, Bhatnagar (1958) conducted ecological and physiological studies in some problem areas of Champion A_1 A_2, B_3 and B_4 types of sal forests of this State and observed that (i) regeneration of sal comes up well in certain plant communities and not in others, (ii) high amounts of organic matter in the top soil has a depressing effect on the growth of sal seedlings (iii) root competition between sal seedlings and herbaceous and shrubby undergrowth seriously affects the growth of the former and (iv) foliar analysis indicated a regular and direct relation often linear between the leaf concentrations of some minerals and the quality of sal.

The present paper deals with the findings of the author discussed elsewhere (Srivastava 1963) on the inter-relationships of certain environmental factors with the occurrence of natural regeneration in different types of sal forests of Uttar Pradesh.

DISTRIBUTION OF SAL FORESTS IN UTTAR PRADESH

In Uttar Pradesh sal is confined to the humid tropical region fringing the hills forming the main mass of most valuable moist deciduous forests. The total

forest area of this State is 39873 sq kilometers about 14 % of the total land of which sal forests occupy 090 sq kilometers The normal altitudinal ange in which sal occurs lies in between 152 to 915 meters but in outer Himalayas ascends to 1,220 meters and occasionally to 1,523 meters. In places especially in eastern U P sal extends some distances out in plains.

Climatologically the whole tract may be considered as sub-trop cal with hot summe s, a long grow ng season of about 8 months a mild but definite winter and a definite rainy season.

In U P sal occupies both hilly as well as plain grounds The northern part comprises of the Himalayan formations with siwaliks clinging to the southern marg n wh le the southern portion consists of alluvial formation. As regards soil, sal is capable of growing on various types of soil provided the water content is neither too low nor too high and the drainage is satisfactory Soil varies f om heavy clays to dry sands and boulder beds with variable amounts f humus.

The main features of the va ious types of sal forests in U P as classified by Champ on (1933) are given in table below

TABLE

Distrib tion f types of sal forests in Uttar Pradesh

(Mainly based on Champ on. 1933)
Seth 1951)

F rest types	Area in thousand hectares	Chief rock nd soil	Distribution	O tstanding features
A_1 —Dry Siw lik	98	Siwalik sand rock & conglomerate	Kalagarh Dehra-Dun, Lansdowne Ramnagar, Saharanpur divisions	Regeneration ge nerally deficien
A_2 —Dry Gangetic	37	Sandy alluvium	Jaspur Ramnagar divisions Motipur Bahraich division, Dhaulkhand,Saharanpur division	Regression to xerophytic with drough mortality
B_1 —Moist (Siwa lik) western hill sal	156	Nahan sandstone	H ldwani, Ramnagar, Kalagarh, Lansdowne Gonda divisions	Adequate regene ration
B_2 —Moist (Gangetic) high level alluvial sal	97	Alluvial loamy soils, locally gravelly (*Bhabar Duns & dunars*).	Dehra Dun, North Kheri, Haldwani, Pilibhit,Ram divisions	

burning and (iii) hoeing for soil aeration in moist forests while (i) introduction of underwood as soil protection and (ii) preventing run off of rain water and encouraging of percolation into the soil by cultivation and trenching in dry type sal. Troup (1921) on the basis of Hole's work and his own experience gave some similar suggestions fo obtaining satisfacotry regeneration of sal. Champion (1933) while writing his monograph on sal on the basis of available data and his own wide experience, stressed the need for detailed knowledge about successional trends of the various sal forests so that proper silvicultural operations may be adopted for obtaining natural regeneration. After explaining the possible trends of succession in different types of sal forests in brief he suggested proper silvicultural and management practices that would favour progression in dry types while checking it in the moist types, which could help in the establishment of seedlings.

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DISTRIBUTION OF SAL FORESTS IN UTTAR PRADESH

In Uttar Pradesh sal is confined to the humid tropical region fringing the hills forming the main mass of moist and semi-moist deciduous forests. The total

Lagerstroemia parviflora Terminalia tomentosa and *Syzygium cumini*. The main communities of this faciation are

3 *Lagerstroemia-Ehretia* community

4 *Terminalia-Lagerstroemia-Bridelia* community

5 *Terminalia-Syzygium-Cordia* community

III Moist facies These facies generally occur on alluvial formation. The ground is generally flat along the river terraces or *thaplas* forming gentle southern slopes. Generally these localities are traversed by streams which account for the better moisture conditions and the presence of *Syzygium cumini* and *Litsaea chinensis* The only wide-spread community of this faciation is—

6 *Terminalia-Syzygium-Litsaea* community

The floristic composition, structural variation and the regeneration status of these communities have been described in detail in the text. In each community societies constituted by the species of sub-dominant strata (shrubs and herbs) have been recognised with special reference to their effect on natural regeneration of sal.

Distribution pattern of ground vegetation Subordinate vegetation commonly called ground cover plays an important role in the life of forests. \ot only does it exert a direct influence upon soil and trees but its character may also be an indicator of soil and moisture conditions on which it subsists. Therefore, in the present tudies an attempt was made to determine the distributional pattern of subordinate flora with the help of statistical principles especially the biserial product moment method. It has been found that important species in each community are distributed in well defined manner forming groups or mosaics. The occurrence of sal is associated with one of these groups in every community which may be called as 'regeneration complex group" and which indicates the sites suitable for natural regeneration. These studies clearly indicate that the vegetational diversity is loosely associated with environmental differences and the vegetational pattern represents the summation of the plant responses to the corresponding environmental pattern.

Indicator species for sal natural regeneration The data collected for recognising the communities was also utilized to determine the indicator species for natural regeneration of sal. Both favourable and unfavourable species have been determined on the basis of presence or absence of these species in distinct association with sal seedlings.

Species which generally indicate favourable sites for presence of sal regeneration in various communities are *Lagerstroemia parviflora Syzygium cumini, Miliusa velutina Ehretia laevis Schleichera oleosa* (seedlings) *Litsaea chinensis Clerodendron petasites, Murraya koenigii Pogostemon plectranthoides Moghania chappar* and *Millettia auriculata*.

On the other hand species which generally indicate unsuitable conditions are *Holarrhena antidysenterica Diospyros tomentosa Bridelia retusa, Semecarpus anacardium Mitragyna parvifolia Helictres isora* and *Tiliacora acuminata*

Most of these species are also indicators of moisture conditions of localities which by far play the most important role in the process of sal natural regeneration in these forests. Some species may play a dual role indicating good or poor regeneration conditions depending mainly upon the successional status of communities and the status of the species within it.

Succession Succession studies indicate that so far as the trends in secondary succession are concerned, the two communities of dry facies *viz Terminalia Ehretia-Lagerstroemia* and *Ehretia-Lagerstroemia-Cassia* represent parallel retrogression stages, conditioned by edaphic and biotic factors, and on adequate protection both will tend to evolve into the *Lagerstroemia Ehretia* community On further deterioration of the conditions these communities will degrade to dry mixed deciduous forests without sal and ultimately to short savannah.

The three communities of moderately dry facies occupy different positions on the successional gradient. *Lagerstroemia-Ehretia* is the most stable community attaining almost a climax stage. *Terminalia Lagerstroemia-Bridelia* community represents rather a lower stage towards the drier end On deterioration of conditions it will regress to dry mixed deciduous forests without sal, while if progression sets in, it will tend towards *Lagerstroemia-Ehretia* community On the contrary *Terminalia-Syzygium-Cordia* community represents a higher stage in progression than the *Lagerstroemia-Ehretia* community which on further improvement in the prevailing moisture conditions will progress towards *Terminalia-Syzygium-Litsea* community while on retrogression it will tend towards *Terminalia Lagerstroemia-Bridelia* community

Terminalia Syzygium-Litsea community of the moist facies represents rather a climax stage under the prevailing conditions. However if left undisturbed it will attain a post-climax stage in which the proportion of the evergreen component especially in the lower storeys will increase at the expense of sal. In view of these facts, in order to improve the stocking of sal and obtain adequate regeneration, it is necessary to resort to practices which help in maintaining the balance in such a way that too much progression resulting in moist evergreen forest with less proportion of sal or excessive retrogression resulting in deciduous forest devoid of sal is prevented

The probable trend of primary succession leading to the formation of mixed sal forest have also been described in detail

PART III

Seasonal variation of nutrient content of leaves In order to use foliar analysis as a means of determining the nutritional requirements of plants and the

fertility status of a given soil it is essential to determine the proper time of sampling the leaves at a definite physiological age. With this object in view seasonal fluctuations in the mineral composition of sal tree and seedling leaves were examined. The results indicate a definite rise in the concentration of ash sesquioxides, calcium and potassium in the early phase of the growing period *i.e.*, from March to June both in tree and seedling leaves and a sudden fall during June-September *i.e.*, in the latter phase of the growing period. The insufficient light available during this period due to heavy clouds may result in slowing down the photosynthetic activity and heavy rains may cause some leaching out of nutrients from the foliage. There is a decrease in the concentration of most of the nutrients during the yellowing period due to backward translocation. It is, therefore, concluded that the leaf samples should be collected in May June or in January February when the concentration of most of the nutrients is high However exact time of collecting leaf samples will vary according to the weather conditions of the locality and the elements to be studied because a uniform trend was not observed in case of all elements. Also the leaves should be collected at a comparable stage of growth preferably fully mature.

Effect of moisture supply on the growth and nutrient uptake of sal seedlings Insufficient availability of moisture during the critical period of growth of sal seedlings is considered to be by far the most important factor inhibiting natural regeneration especially in the dry type sal forests. However experimental data on the actual moisture requirements of this species is lacking The optimum moisture range required for satisfactory growth of sal seedlings was determined by means of an especially designed apparatus. Side by side, the effect of varying moisture content on the availability and uptake of nutrients and on the consequent growth response was also studied. The results revealed that in loamy soils sal seedlings on an average require moisture to the extent of 85 % of water holding capacity and 12 per cent more than the moisture equivalent for optimum growth and there is an appreciable reduction in height increment below and above this range. Plants growing within the optimum range also absorbed greater amounts of nutrients especially calcium, potassium, and phosphorus. It follows that sal is a high moisture loving species and even small increase in soil moisture stress during the growing period can cause appreciable reduction in plant growth. The analysis of the residual soils also indicates that the transfer of nutrients in the soil matrix is a slow process and a local deficiency may develop in the rooting zone which is not compensated by the diffusion of nutrients from neighbouring soil regions.

Studies on root development The important effect of physical nature of soil on the initial development of sal seedlings is exerted through the profile morphology and the nature of stratifications in soils and subsoils. This applies particularly to the upper Gangetic alluvium having azonal soils where a shallow layer of loamy top-soil is often underlain by coarse sand. Sometimes there are several sand strata at different depths. An experiment was con-

its availability will invariably prove beneficial to the growth of sal seedlings. On the contrary application of potassium and phosphorus fertilizers do not seem to have a significant effect on the development of sal seedlings in such soils.

The relationship between growth and mineral nutrition of sal Sand culture experiment was conducted to determine the optimum requirements of sal seedlings. For this purpose, the seedlings were grown in pots having silica sand as the substratum and were supplied with two doses of calcium and magnesium equivalent to 300 lbs. per acre and 600 lbs. per acre and three doses of nitrogen, potassium and phosphorus equivalent to 100 lbs. per acre, 300 lbs. per acre and 600 lbs. per acre in all combinations and permutations.

The results indicate that each element exerts a significant influence on the growth of the seedlings and the presence of each component had a profound influence on the effect exerted by others. While 300 lbs./acre of calcium and magnesium appears sufficient for the proper growth of sal seedlings the best results for N P and K are obtained near the (3) level of nitrogen (2) level of potassium and (1 5) level of phosphorus. Higher amounts of N K and P may result in slightly better results but the effect will not be proportional to the strength of nutrient elements while quantities lower than the above will definitely result in decrease of dry weight and height increment. The significance of interactions shows that the effect of each element is modified to a varying degree by the presence of others and therefore it is essential to take into consideration the question of balance between different nutrients The interactions are significant in case of N×P and N×K but not for P×K showing that Nitrogen is the factor through which the modifying influences are felt and that there is no mutual relation between P and K levels regardless of the nitrogen content.

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ON PARASITIC GASTRITIS IN *EQUUS ASINUS**

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INTRODUCTION

Parasitic gastritis in equines is associated with *Trichostrongylus axei* (Cobbold, 1879) Railliet and Henry 1909 and the three species of *Habronema* Diesing 1861 The former is known to cause patchy gastritis in which the mucosa becomes thickened and folded. *T axei* is also highly pathogenic in sheep (Gibson 1954) and other ruminants (Lapage 1956) Because of its wide distribution it has been studied from the point of view of its life history bionomics and pathogenic effects. Of the species of *Habronema H megastoma* Seurat 1914 [*D aschia megastoma* (Rudolphi 1819) Chitwood and Weh 1931] because of its association with tumour formation, is of great pathogenic significance The two other species—*H microstoma* (Schneider 1866) Ransom 1911 and *H muscae* (Carter 1861) Diesing, 1861 invade the gastric mucosa in varying degrees—the worms lying free in the lumen or on the mucosal surface, superficially or embedded with copious mucus around them All these three species had earlier been reported in asine host from this Department (Rai and Srivastava, 1958)

The gastric mucosa in these infestations encountered during collection work from twentyeight donkeys autopsied, revealed prominent lesions of gastritis. Scrapings yielded worms-both trichostrongylid and spirurid. The tumours of *H megastoma* ranging from 1/2 inch diameter to a size of 5½ inches diameter were observed in seven of these cases and the small-sized tumours, upto three in number were noticed once while two such tumours occurred in two cases.

The pieces of the lesioned tissue from serially cut stained sections provided useful data on the distribution at different depths of the mucosa, of the harboured stages of these parasites. Usually the attack did not ... the mucosae muscularis. In one case however a worm was cut on the submucosal side apparently after successful penetration of this layer This encapsulated stage has been identified as a male specimen of *T axei*. The pathological changes, in relation to gastritis involved in consequence of these invasions are briefly described below

OBSERVATIONS

T axei

Five of the twentyeight donkeys yielded this species which ... met in the thirteen ponies also examined post-mortem. The ...

* Part of the Thesis submitted ... degree ...

this infection were observed as ring-worm like areas of varying sizes. Only one of the positive cases showed irregularly circumscribed patches with well marked raised boundaries *i.e* the characteristic ring worm like appearance (Fig 1) These lesions measured 1½ cms in diameter while Rai (1959) observed smaller areas w th 2 7 mm. diameter The mucous membrane was greatly thickened in the form of folds and plaques which denoted congestion Over these plaques a thick layer of mucoid exudate yielded numerous specimens of *T axei* a large number being present at the periphery of the lesion. Another typ of lesion, mostly met with consisted in the form of plaques also of varying sizes but without any ring worm like appearance. Here also the mucosa was greatly thickened and congested in the form of pin point ulcers with the surface thickly covered with copious mucus.

In the series of the stained sections of these two categories of lesions the extent and nature of the pathological changes were assessed. In these sections a large number of male and female worms were cut at various depths of the gastric coat with the anterior ends in some lying embedded deep in the mucosa (Fig. 2) with the posterior regions of the body and the eggs occurring mostly superficially (Figs. 3 to 6) In one case, however even the muscularis mucosae was approached

In addition to a conspicuous degree of erosion and attendant sloughing of the mucosa the epithelium was hyper-plastic. Hypersecretion of mucus by the glandular epithelium and a prominent desquamation of the epithelial cells were also revealed. The connecti e tissue of the lamina propria, situated betw een the glands exhibited a moderate degree of mononuclear infiltration and at places a few of the eosinophils were recognisable (Fig 7) Besides, focal areas of heavy lymphocyti infiltration in the lamina propria were also revealed such foci appearing like lymphoid follicles (Fig 8) The surface epithelium in some cases, was eroded to a degree that the gastric glands had become exposed Cellular debr s and necrotic material was accumulated on the urface as d phtheritic type of membrane visil le only in a few sections on account of its ea y deta hment during sectioning A hypertrophy and increa sed alveolisation of the gastric glands were al o revealed with the lumen of the glands showing some eosinophilic exudate. Few of the gastric glands appeared somewhat h pertrophic and hyperplastic with the result that in tead of a single layer of lin ng epithel um the appeared to be lined by many layers which had hanged the normal feat res. These histopathological changes agreed essentially to the pathological picture described in *T axei* infections in horses (natural and experimental) by Leland *et al* (1961) excepting for the fact that the pin-point e as of alcification mentioned by these authors were not seen in the mucosa the eosinophils we e also not many and the occasional presence of alveolar ca ities observed in experimental ca es were not revealed. In addition hyperaemi too was not e ident.

One worm, l ng on the outer su face of the muscularis mucosae was cut inside a small nodule (Fig) hich in sections, sl owed a heavy infiltra

tion of lymphocytes and a number of eosinophils. Fibroblasts were also seen in this situation. This invasion has resulted from a male trichostrongylid. The submucosa, muscular coat and the serous layer all appeared almost normal except for a moderate degree of congestion in the blood vessels of the submucosa.

Habronema spp.

All the three species of *Habronema* were encountered in great numbers in the cases available in the present survey. The pathological picture in infections, co-existing with *T. axei* could better be assessed alone in a histopathological study of the lesions harbouring the worms. However, in cases of infections, purely from *Habronema* spp. the serial sections indicated clearly the nature and extent of the damage done. Grossly lesions consisted of a moderate thickening of the gastric mucosa with many diffuse white plaques and a thick layer of whitish viscid mucopurulent mucoid exudate covering it. This was in respect of both the species *H. microstoma* and *H. muscae*. In *H. megastoma* tumours of 1/2 inch to 5½ inches in diameter, few worms were observed through their openings, while the latter itself was revealing some pus. Congestion was apparently absent in these lesions.

Two series of the serially cut stained sections of the lesions associated with *H. microstoma* and *H. muscae* showed a chronic catarrhal type of inflammation. The worms generally lying superficially on the surface of the mucous membrane had in some reached nearly to the middle region of the mucosa (Fig. 10). A thick coat of mucus with the epithelial cells necrosed and desquamated was visible on the surface. The gastric glands were hypertrophic and hyperplastic. As a result of hypersecretion of the mucus the lumen of the affected glands contained an eosinophilic mass. In the lamina propria a generalised type of infiltration with lymphocytes and eosinophils was revealed and at few places lymphocytic aggregation was observed in the form of a lymphoid follicle. The blood vessels in the mucous membrane were only moderately congested but the muscularis mucosae, sub-mucosa, muscular coats and the serosal layer were all perfectly normal.

Remarks

T. axei infestations of horses had been reported by Baker (1933), Gordon (1933), Oxspring (1934), Britton (1939), Christensen (1945) and Leland *et al.* (1961). The nature of the gastric lesion, the anaemia and debility produced in consequence and the over-all pathological changes due to this species are all available in these papers. The survey so far undertaken locally on caballine and asine hosts, has revealed that this parasite is of widespread occurrence in donkey. This type of incidence may also occur in other regions of the country as well. A heavy infestation in ponies may comparatively prove more pathogenic leading to a greater degree of attendant disorders. Further, its transference to our domestic ruminants which share the same grazing areas may, in infested pastures, be a source of greater trouble in view of the findings of Gibson (1954).

Fig. 1 Photograph of portion of stomach showing characteristic ring-worm-like lesion.



Fig. 2 A part of section of stomach showing the anterior end of the worm cut, reaching the muscularis mucosae X 179



Fig. 3 Part f anothe ection of stomach showing spicule t in the mucosa X 170.



Fig 4 Part of an r ec ion of toma h showing male bursa cut in the mucosa. X 170.



Fig. 5 Part of another section of stomach showing genital opening and ovijector cut in the mucosa, X 170

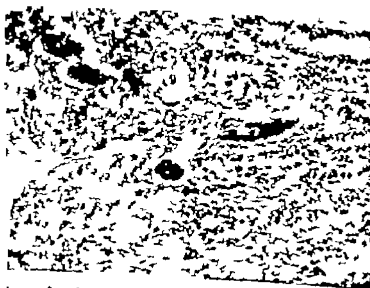


Fig. 6 A part of another section of stomach showing eggs cut in the mucosa. X 200.

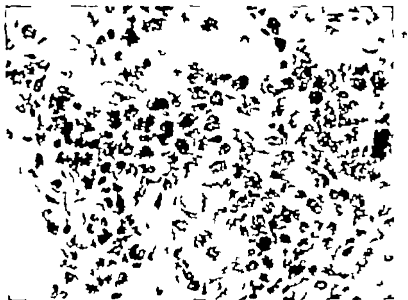


Fig 7 A part of another section of stomach showing eosinophilic infiltration in the mucosa, X 500

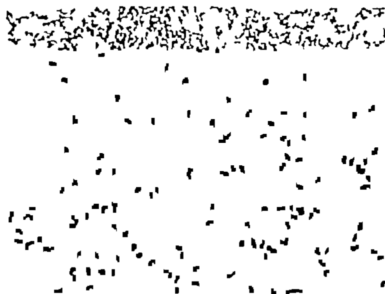


Fig 8 A part of another section of stomach showing lymphoid follicle in the mucosa, X 220



Fig. 9 A part of another section of stomach showing a male worm cut inside a small nodule located outside the muscularis mucosae. X 200



Habronema sp.

Fig. 10 Part of a section of stomach showing the anterior end cut in the mucosa. X 300.

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